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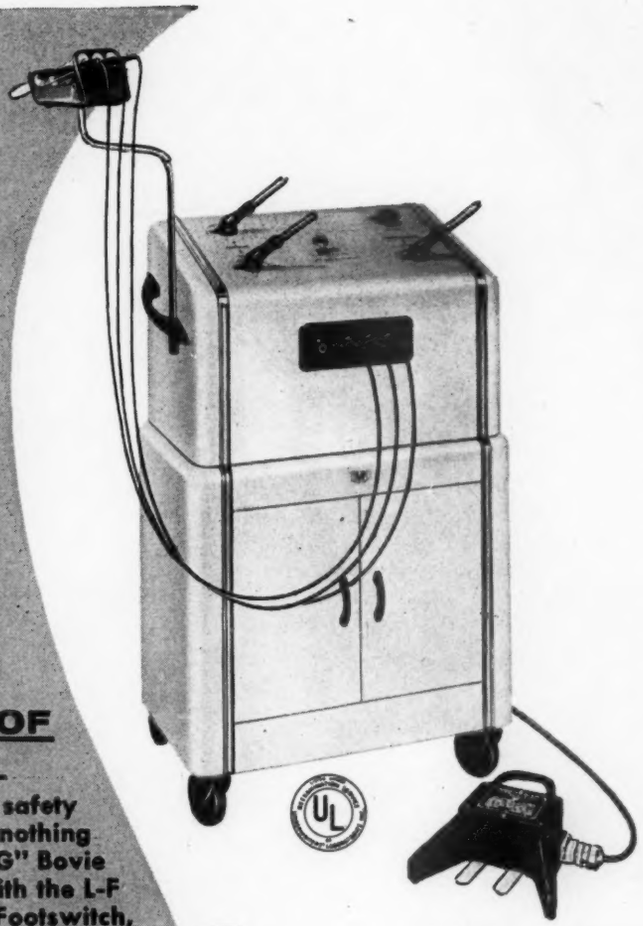

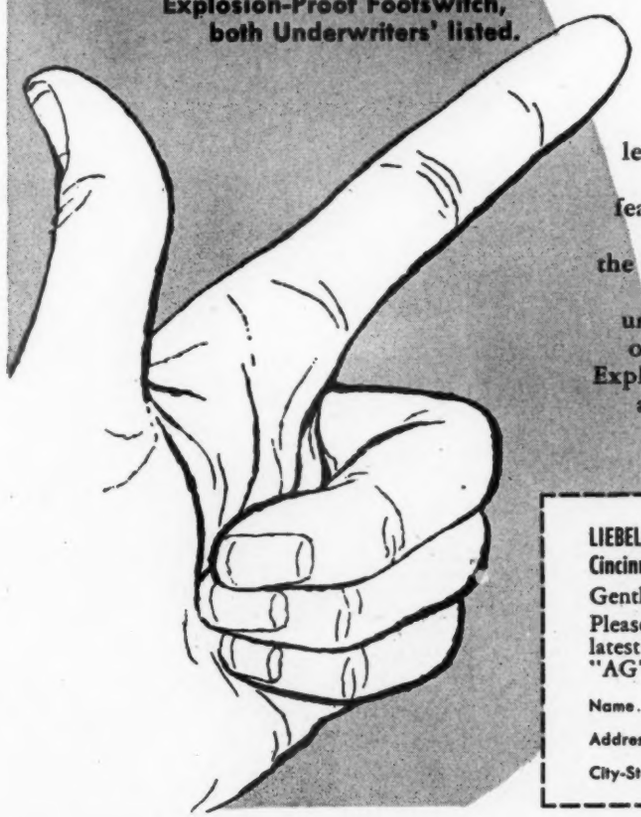

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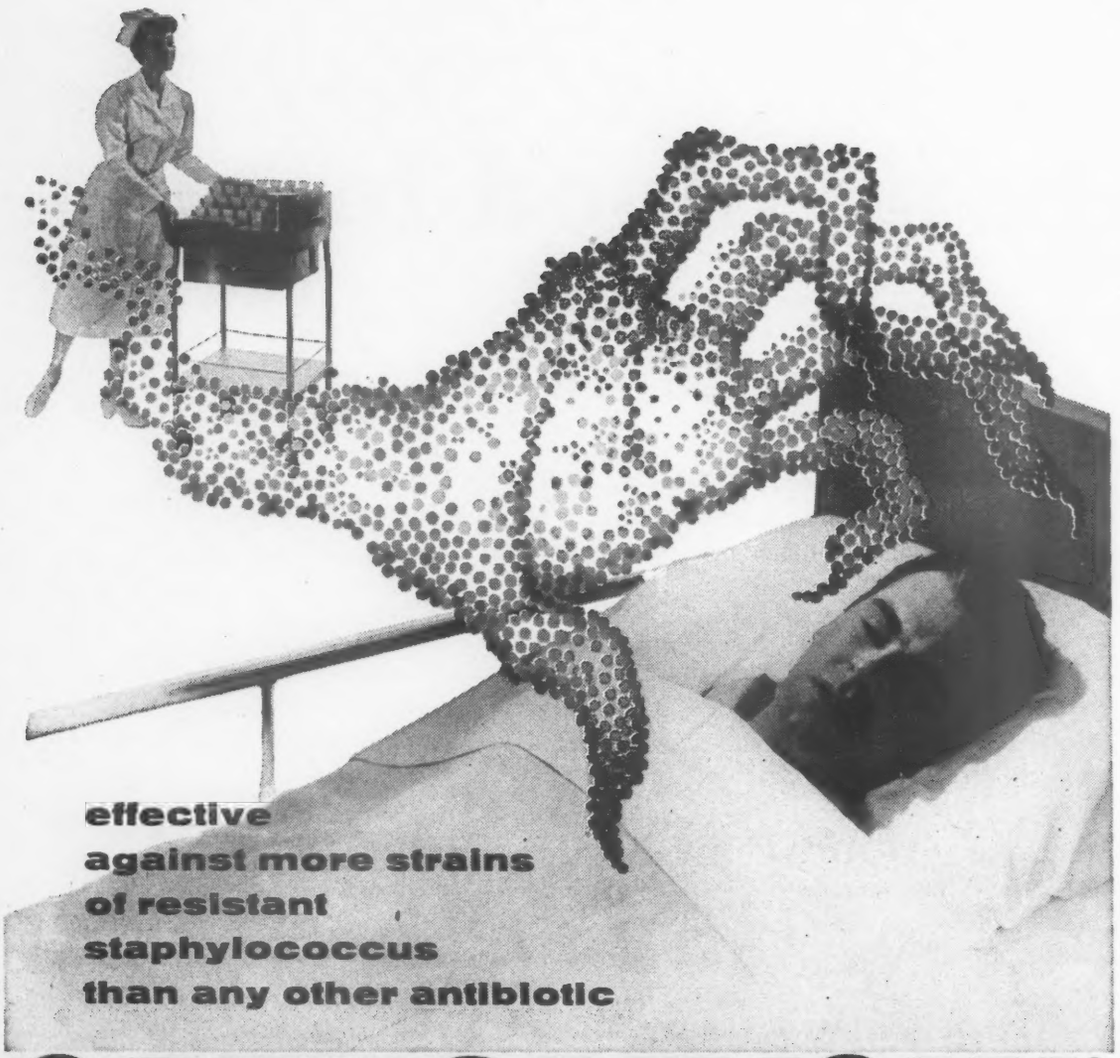

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1. Pulaski, E. J., and Isokane, R. K.: Surg., Gynec. & Obst., 104:310, March 1957.
2. Petersdorf, R. G., Curtin, J. A., and Bennett, I. L.: Arch. Int. Med. 100:927, December 1957.

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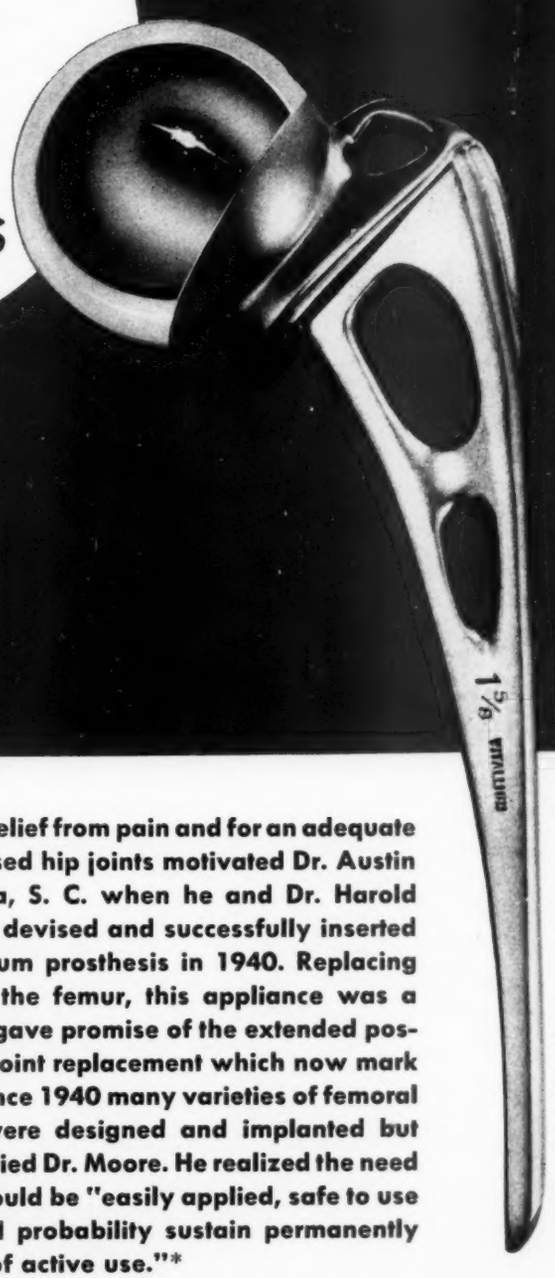

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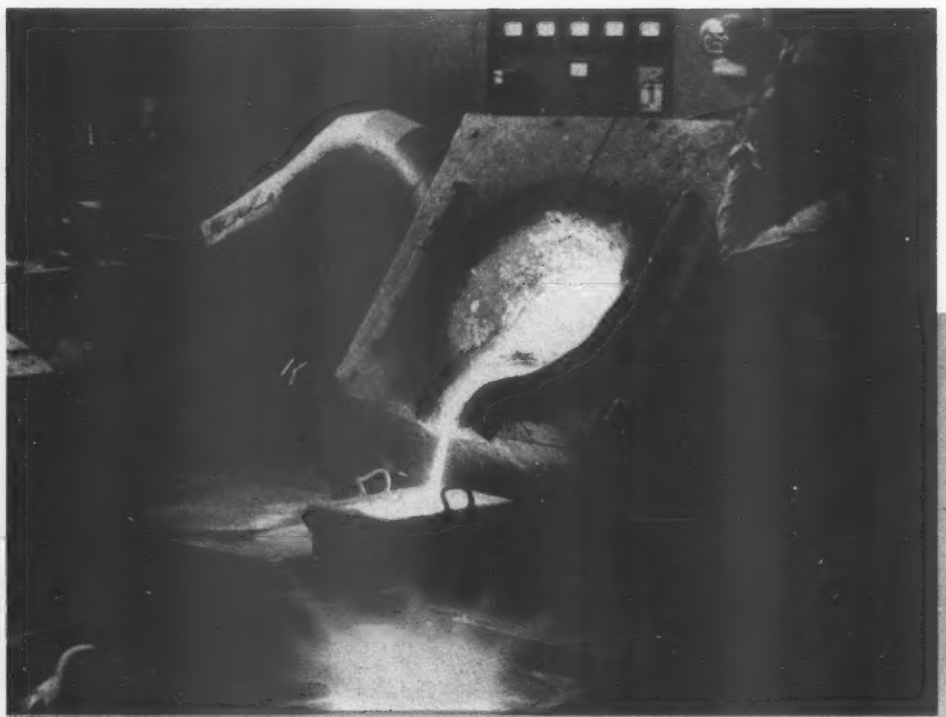

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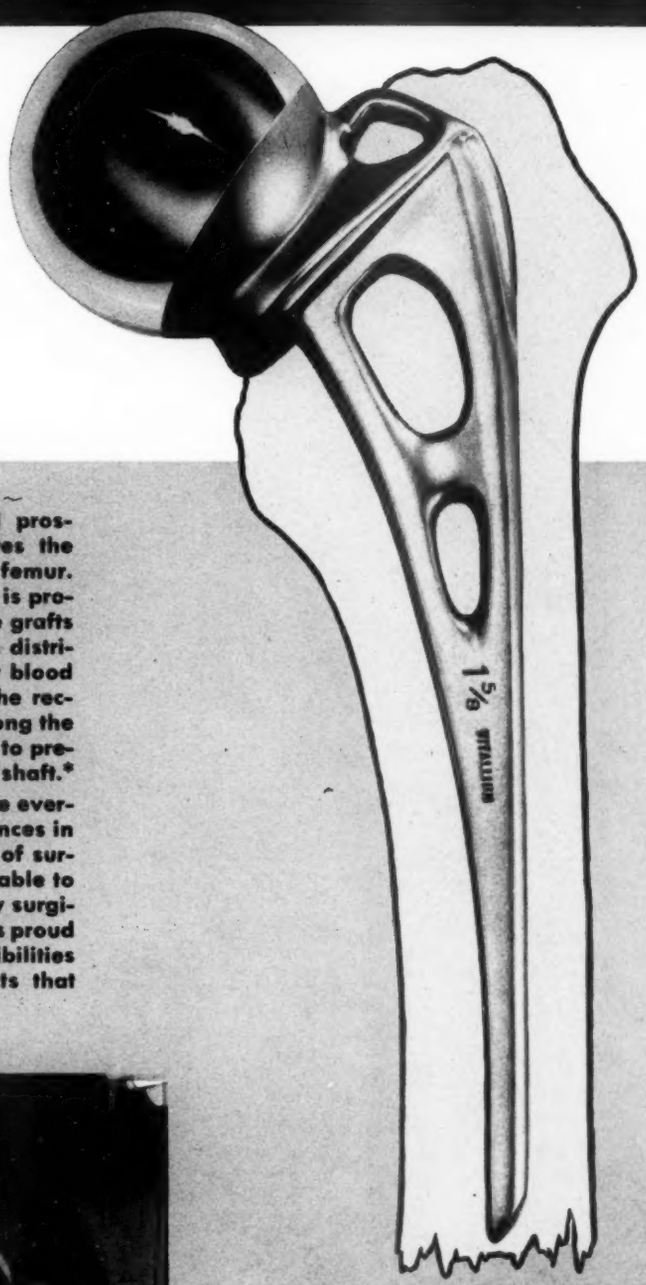

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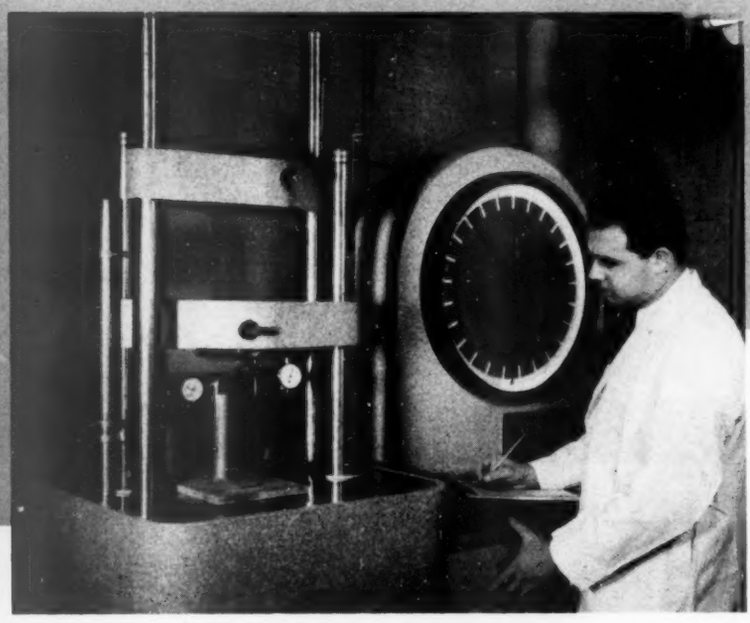

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*Moore, Austin T.: The Self-Locking Metal Hip Prosthesis, J.B.J.S.—39A, No. 4:811-827 (July 1957).

*Moore, Austin T.: Metal Hip Joint, A New Self-Locking Vitallium Prosthesis. South. Med. Journ. 45: 1015-1019 (Nov. 1952).

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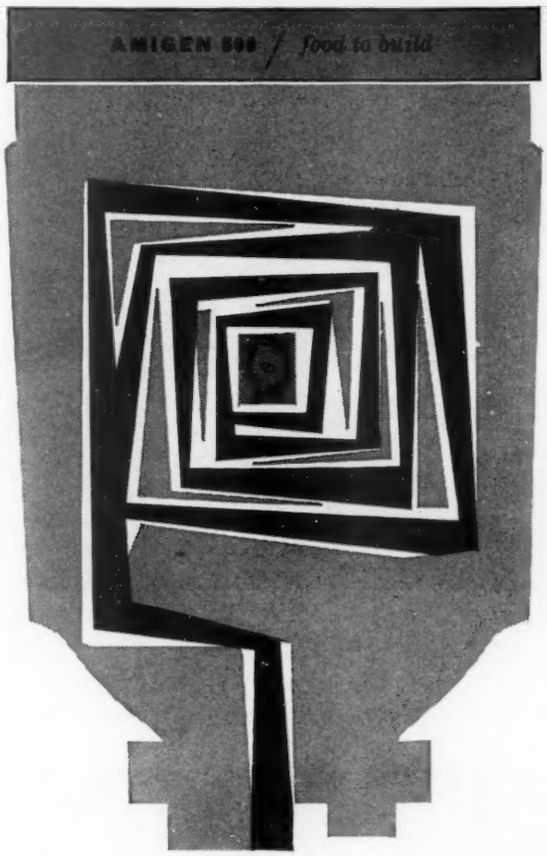

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1. Grayzel, H. G., and Schapiro, S.: Western J. Surgery, Obstet. & Gyn., Oct. 1956.

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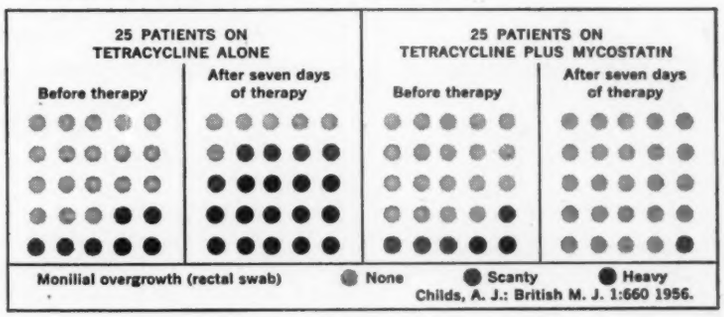

Childs, A. J.: British M. J. 1:660 1956.

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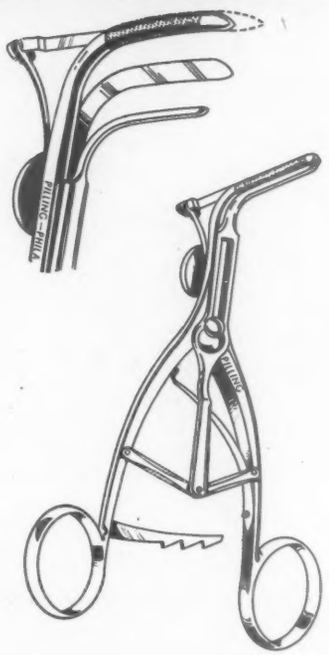

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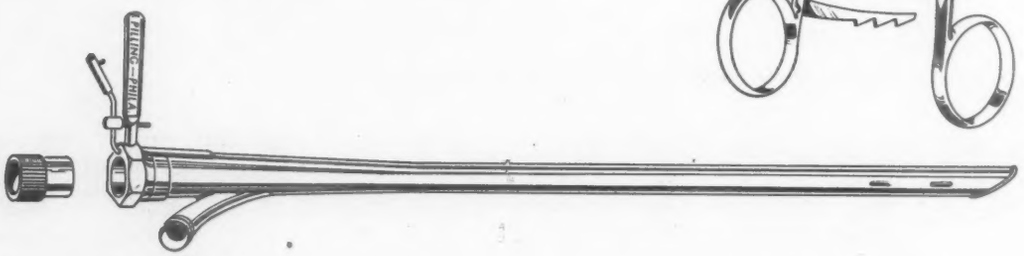

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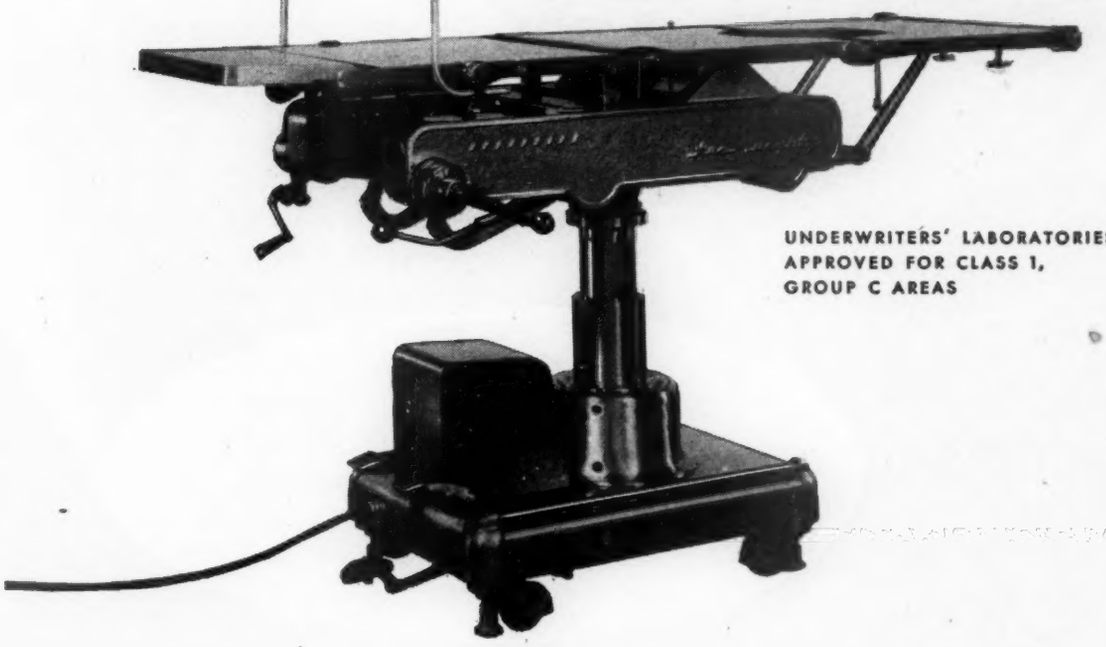

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*Martin, E. A.: Roberts' Nutrition Work with Children, Chicago, The University of Chicago Press, 1954, pp. 141-146.

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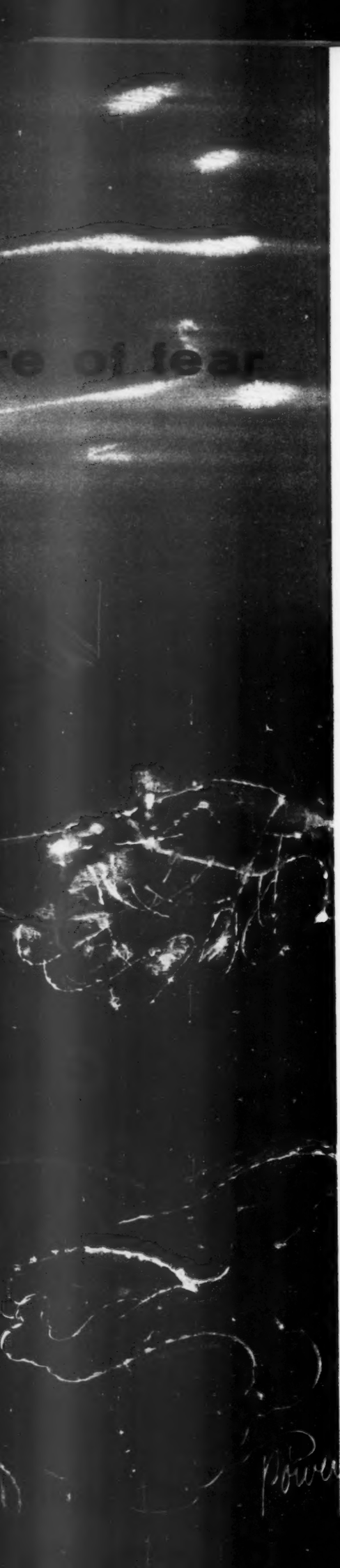

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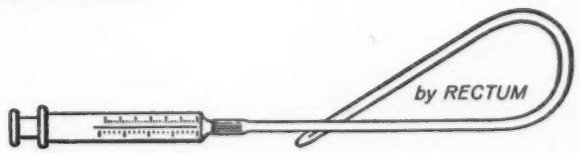

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The nutritional statements made in this advertisement have been reviewed by the Council on Foods and Nutrition of the American Medical Association and found consistent with current authoritative medical opinion.

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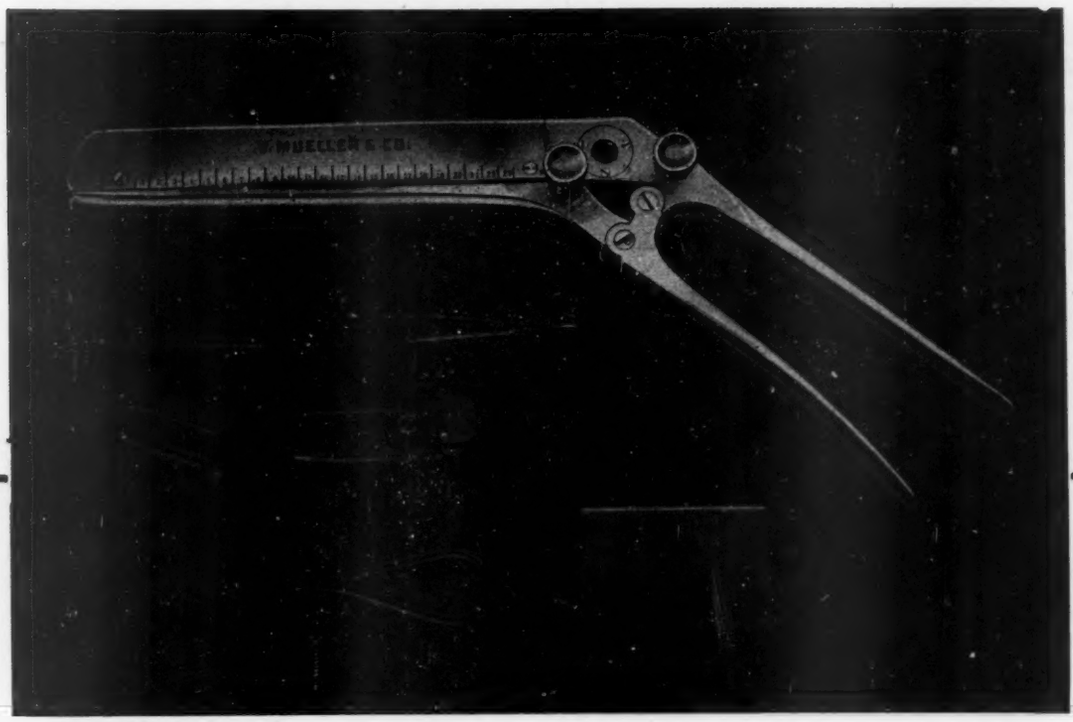

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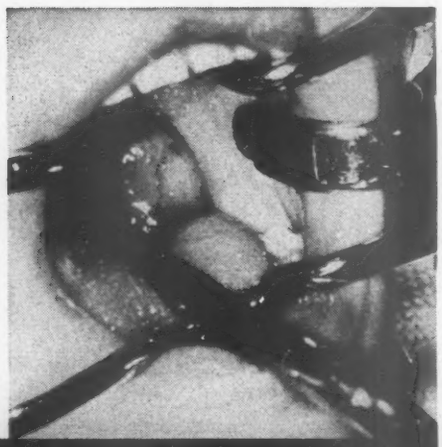

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*Pat. Nos. 2,581,850; 2,506,294
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1. Ryan, E. R.: A New Aid to Tonsil and Adenoid Surgery, *Clinical Medicine*, 5, 327 to 331, (March) 1958.

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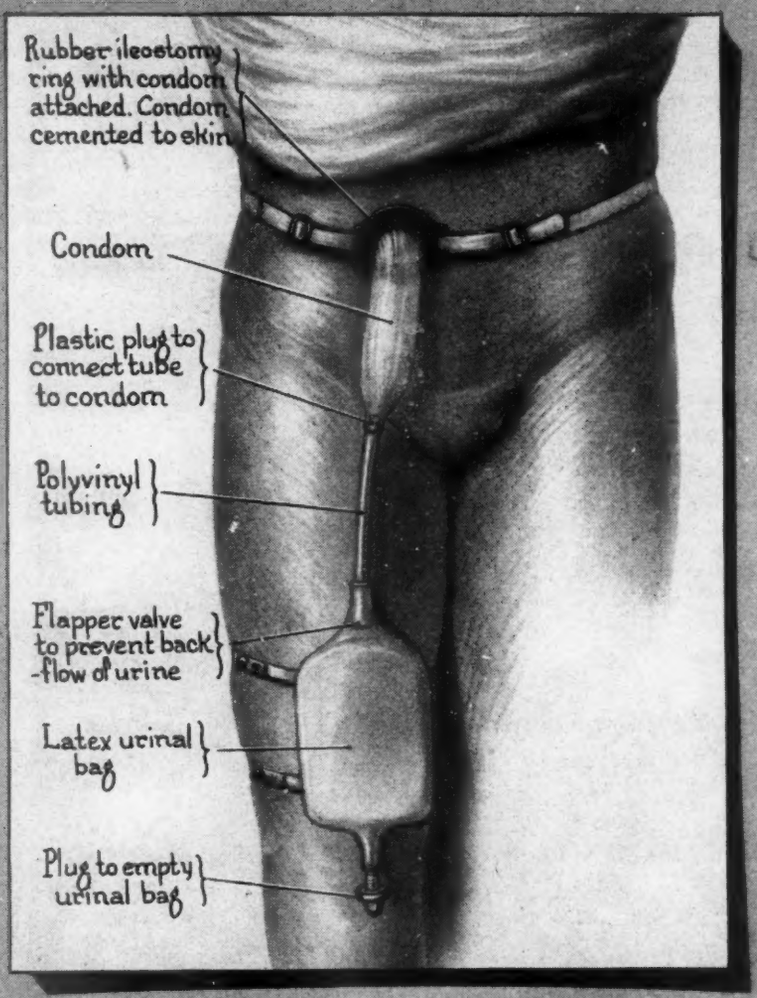
Rubber ileostomy ring with condom attached. Condom cemented to skin
Condom
Plastic plug to connect tube to condom
Polyvinyl tubing
Flapper valve to prevent back-flow of urine
Latex urinal bag
Plug to empty urinal bag

FEATURES

- Can be applied at operating table upon completion of ileostomy.
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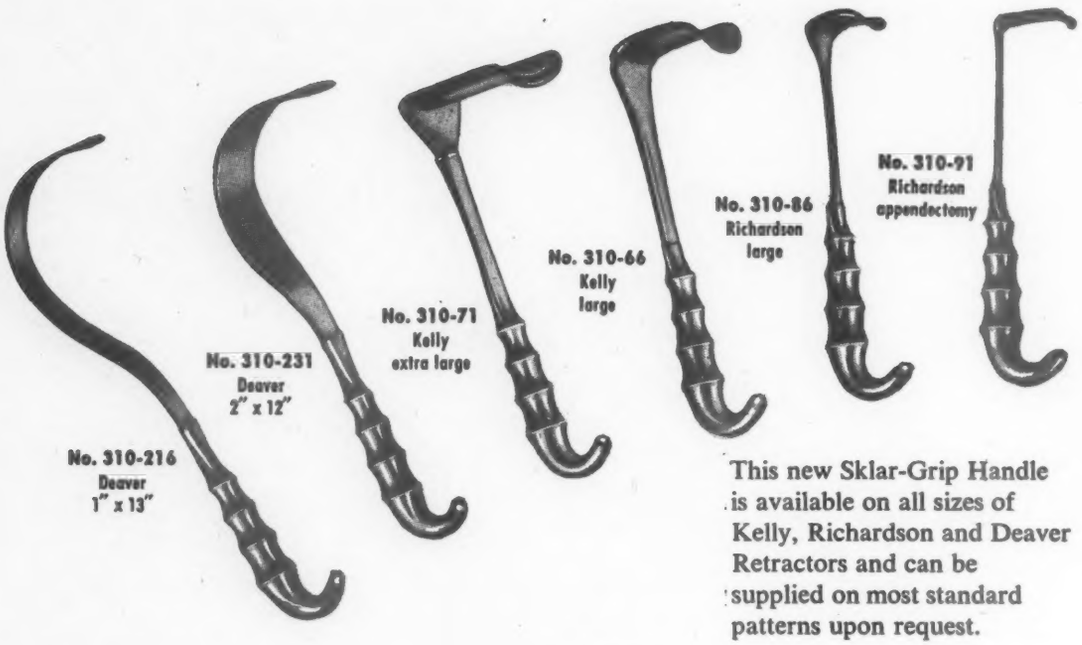

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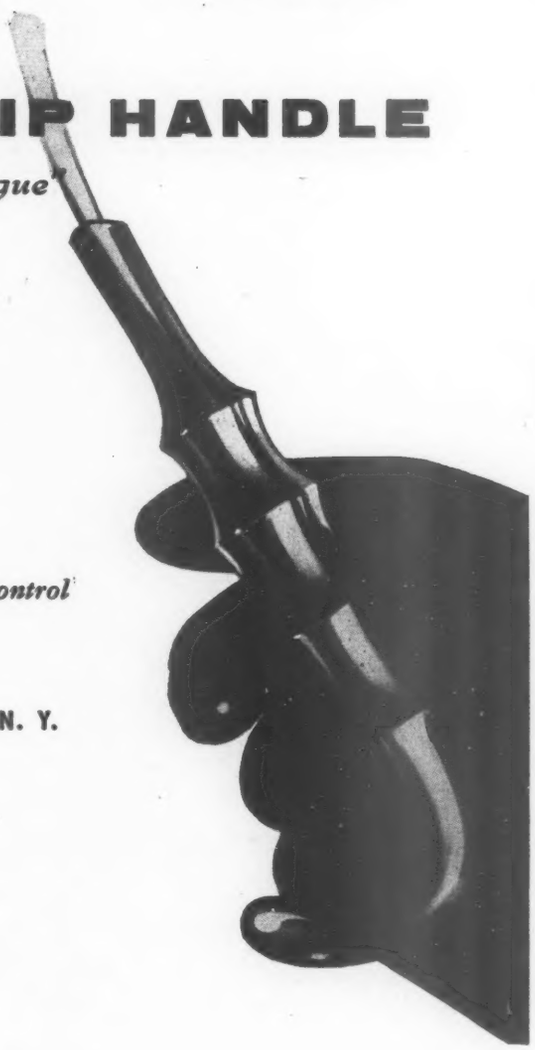

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The American Journal of Surgery

VOLUME 95 APRIL 1958 NUMBER FOUR

PRESIDENTIAL ADDRESS

Trauma—Twenty Years and After

SHORT of twenty years ago this Association was formed ". . . for the cultivation and improvement of the science and art of the surgery of Trauma and allied sciences, the elevation of the medical profession and the consideration of such other matters as may properly come within its sphere." It would be presumptuous to assume that we could assess accurately the success which has attended our activity, or determine how well we have approached the goal as set forth in our articles of organization. Since 1938 there has been an increased interest in the problems of trauma, not only in most segments of our profession but also by the public at large.

We have progressed beyond expectation toward the attainment of our goal. In his organizational address, Dr. Edgar Gilcreest pointed out that the subject of trauma was rarely discussed at meetings of the major surgical societies of this country. Today the subject of trauma is widely discussed in other surgical associations and the American Board of Surgery regularly includes problems of trauma in their examinations.

In the first presidential address presented here at Hot Springs, Dr. Kellogg Speed pointed out that it was not the primary desire or intention of The American Association for the Surgery of Trauma to add to the schisms in surgery with an organization of limited scope or viewpoint, but rather ". . . to attempt an amalgamation and calling back into the fold of the well trained general surgeon of those interested in the maintenance of high surgical skill and scientific development in the phases of surgery which have to do with trauma, its immediate and distant effects and complications." We have fulfilled this concept well in that our programs have been of a general nature, embodying topics of basic importance as well as technical detail. Our membership consists of outstanding individuals whose interest is limited to special fields as well as those with more general interest. Trauma being no respector of anatomical boundaries, our Association has been and continues to be a common meeting ground for those interested in trauma without regard to Board designation.

It is not my purpose now to review our fruitful past, but rather to consider additional and present problems and future goals. Two objectives appear strongly before us if we are to continue to make contributions to the progress in the field of trauma.

The first of these is to give thought to the extension of our educational opportunities for training and research in trauma, and the second is to lend our efforts toward decreasing the number and severity of accidents.

The original interest in trauma was centered in surgeons; in fact trauma was the primary reason for the existence of surgeons. One has only to peruse the works of Paré, Heister and Baron de Larrey, in fact the works of any of the early surgeons, to note that trauma formed the basis of our art. Even more recently, great and obvious strides were made in surgery during and after each of our wars. Trauma always was and still is basically a surgical problem,

and trauma has always meant more than surgical technic, for no surgeon who deals with the effects of trauma can help but recognize that most injuries should not have occurred and that prevention is important.

Trauma is today our greatest public health problem. It is the leading cause of death in the younger age group (one to thirty-five years) [1], and in addition accounts for most of the crippling of our population. Our salvage rate in terms of life and function depends not only on the degree of skill we exercise but also on the severity of the injury. We have, however, recognized that, as in the case of any disease entity, severity is not a cause for hopelessness but rather is a stimulus for our best efforts.

As in any public health problem, the efforts of the entire medical profession are required as well as the cooperation of the public. Disconcerted and unassociated programs of effort to control trauma have hardly permitted us to keep up with the problem. It brings to mind the remark of the red Queen to Alice, "Now here you see it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that." We have made progress when we consider the increase in traumatizing agents but not in relation to the total number of deaths.

The Detroit Police Department has made a good record in reducing traffic deaths in the City of Detroit, showing a decrease in fatalities where the number of deaths is considered in relation to the increase in the city's traffic. Statistics must be weighted with population, with numbers of traffic miles and many other factors, but the fact remains that we have not reduced the terrific toll of life and limb due to trauma. It does, however, intimate a certain pride in "running fast enough to keep in the same place." There is no reason why it should continue so to be. Despite the surgeons' inherent interest in the problem of prevention, we have done very little about it. We do not have the engineering information or authority to change design of machinery, nor do we have the facility or means of implementation for making the public aware of this grim problem through modern mass media. We do have first hand information as to how accidents occur and what mechanisms are involved; and when new traumatizing machinery is provided the public, we are the first to learn of the new danger. In fact, such mechanisms are likely promptly to become a part of our nomenclature, such as "bumper fracture," the now forgotten "crank fracture," "do it yourself" and more lately "lawn mower injuries." We cannot help but look beyond the machines to their effect on our patients. We have much to offer the mechanical engineer in the way of suggestions for safety factors and the safety engineer in regard to the mechanisms of injury, even if the accomplishment of most of these must be left to proper experts.

The use of advertising media has done much to bring before the public a mass consciousness of the importance of injuries. Mass consciousness about safety is unfortunately not necessarily transposed into personal carefulness. All too often this is considered as affecting other people. The relationship between the doctor and his patient offers a means of developing a personal sense of safety.

Concerted efforts at control of cancer and heart disease, as well as problems of numerically less important concern such as poliomyelitis and tuberculosis, have been made. In the fight against tuberculosis, in which so much progress has been made, the cooperative effort of lay and medical groups working together as one team was essential. Tuberculosis is still a problem but it has been whittled to size. Those in the medical profession most interested in trauma do little about prevention; and those interested in the prevention of accidents make little use of the help which can be obtained from the medical profession, nor do they help much in development of better care of the injured. While it is understandable how these two separate and divergent attacks on this problem came about, combined efforts could yield better results.

Time was when there was concern about the specialty to which trauma rightfully belonged. Since injuries are not always limited to anatomical areas, and since even when they are the whole patient suffers, it is obviously impossible to consider this problem with a limited viewpoint. Jurisdictional disputes are not likely to contribute to advances, and with a problem so great the combined efforts of the entire medical profession and the public are required. We must extend our activities toward encompassing the whole problem of trauma.

[1] McFarland, R. A. The role of human factors in accidental trauma. *Am. J. M. Sc.*, 234: 1, 1957.

We cannot be interested in reparative aspects alone, for the salvage rate will never suffice to decrease the death rate adequately, no matter how accomplished we become. The National Safety Council has been actively engaged in attempts to prevent accidents since 1913 and this alone has not proved to be the whole answer. We must combine our influence, our interest and our abilities with those of important lay groups in combatting the trauma problem if proper progress is to be made.

Education in trauma presents a challenge. This Association has had great concern about adequate training for the care of patients suffering from the effects of trauma. Repeatedly during our meetings there have been discussions concerning the educational opportunities not only in our medical schools but also for residency training in trauma. We have decried the lack of adequate programs for training in trauma. With the development of specialty training programs, opportunities for broad and general training in the field of trauma have been more difficult to obtain. Many recognized general surgical programs have become limited to narrow fields; and if any attention is paid to training in trauma, it is through the farming out of residents to other services where they serve for short periods in effect as interns and the training value is negligible.

It would be a most impractical person who would suggest going back to the good old days when general surgical services cared for all surgical problems, with the surgical trainee in hospitals handling all types of surgical cases including all of the trauma. It is important that we also develop surgeons who centralize their interest in special fields. It would be best if the centralization of interest came after a broad training in general surgery, but even so, specialty training would be necessary.

Our present system was not planned; it just developed. Personal interests as well as problems of organization (the better and more efficiently to get the day's work done), played the dominant role rather than sound educational philosophy. In many hospitals patients suffering trauma are not welcome because they have a tendency to disrupt orderly schedules of work and appointments. In addition, the patient brought into the hospital from an accident causes difficulty in determination of financial responsibility beforehand. With limited budgets in most hospitals, one finds it difficult to criticize the lack of enthusiasm of many hospitals for admission of accident victims.

The lack of opportunity for training in trauma does not excuse those in charge of training programs for not attempting to remedy the situation so that their trainees might have well rounded training. Many have tried to remedy this through an attempt to send their residents to city, county or other hospitals where large numbers of trauma cases are seen. This is usually difficult to arrange effectively because the worthwhile hospitals of this sort have their own well organized residency programs and adequate numbers of residents. It is difficult to see how such institutions could ask their own residents to step aside to provide opportunities for trainees from other hospitals.

Most well run city institutions can provide opportunities for men well qualified in basic surgical principles by a good surgical residency, as junior staff men, for a period after their residency. Funds, interest in education and proper planning must be available. Men who have just finished a good residency would not require too extended training in trauma and need not interfere with, but might rather enhance, the surgical training programs in many of our hospitals where large numbers of injured patients are treated.

Better programs for training in trauma are essential and a stimulus for the establishment of other programs is necessary. A separate board of trauma is not the answer, for there are certainly enough boards to divide our surgical family. Recognition of excellence of ability in trauma care under existing boards, or by other means, would offer a stimulus without adding additional problems.

This Association, as well as the Committee on Trauma of the American College of Surgeons, has had interest in the many short courses which have been conducted by many institutions. These are effective means of bringing the principles of trauma care to those interested. Our own Michigan Committee has been active in presenting the problems of the care of trauma throughout the state by frequent conferences, not only in our universities and at our state medical society meetings but also in small communities throughout the state. This latter type of effort is carried on by other committees on trauma and is of advantage,

for accidents are important in small communities as well as larger ones. Furthermore, trauma is a problem in which all segments of our profession become involved. Therefore it becomes necessary that information about the best methods of care of the injured be presented to all segments of our profession.

I have mentioned the excellent programs presented before this Association and those sponsored by the Trauma Committee of the American College of Surgeons. Much of the material presented has been concerned with original work and has been presented to those whose interest and concepts about trauma are well developed. All too frequently we find ourselves talking to those who need it least. Injuries do not occur only where there are well trained experts. They occur here, there and everywhere, and I dare say that the majority of injuries must be cared for by those least qualified by training and interest to do so. Many of these people have of necessity learned by experience, the dear teacher, to do a reasonable and acceptable job; others do not do so well and work at great expense in life or limb to their patients.

The development of better training facilities and a closer liaison with those most active in the prevention of accidents is our problem and we cannot avoid it if we are to maintain our position of leadership in trauma. Let us then rededicate ourselves to those principles for which this Association was founded. The challenge is great, for trauma is as a pestilence in our land and a scourge to our people. Let us then carefully plan our attack on all fronts, for we cannot win by skirmishes in limited sectors.

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Medical Education in Total War

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MANY centuries ago, with man's discovery that exploding gunpowder could project a missile capable of human destruction, there were those who prophesied the end of all war. Again, today, with the discovery of the destructive potentials of nuclear fission and fusion there are certain military strategists who envision an end of international wars or, in the event of the inadvertent precipitation of a total war, measure its duration in terms of hours, days or at the most weeks. The acceptance of this latter term of reference in survival planning is in itself one of the real hazards to survival, for an attitude of this nature at the best focuses on the plans for an acute short-term national emergency and tends to disregard the necessity for a program geared to a more chronic situation.

Recent research in the area of radioactive fall-out and the development of a "clean" bomb, substantiates the fact that nuclear weapons in the future will be used in the conventional fashion and that the destructive potential will differ from the blockbuster of World War II in a quantitative rather than a qualitative measure.

Failure on the part of our nation to accept the responsibility of medical education under the terms of nuclear warfare may well determine the matter of our very survival. Neglect on our part in this crucial area will relate in a seriously detrimental manner not only to the immediate period of survival and actual conflict but also will be projected into many post-war decades and yield the tragic dividends of inadequate national health.

In defining terms of reference in the attempted solution of this problem it should be remembered that the plans to be discussed relate to an organization of medical education in the face of a total war. Other situations short of this, such as intensification of the cold war or limited foreign wars of the Korean type, will present lesser problems in planning which also should receive the consideration of medical educators. It may well be that certain modifications of the more drastic plans outlined in this paper may prove applicable to less serious situations. At the expense of oversimplification, the problem confronting us may be broken down into two major divisions, each of which in turn will fractionate into smaller segments. The first and more important division embraces the area of personnel and the second that of facilities. Considerations of personnel must include an evaluation of the undergraduate student body and patient, as well as the graduate student and faculty. An adequate study of medical educational facilities must relate to the basic science laboratory and hospital bed as well as the classroom and administrative space.

In the face of issues determining our very survival, educational idealists must be prepared to accept a degree of compromise with perfection. It is unrealistic to assume that medical education will not be faced with shortages, both in personnel and facilities, and that the product of education under these extreme situations will not suffer in terms of quality. Nevertheless, it should be remembered that the degree of compromise necessary will be determined to a large extent by the degree of preparation for such an emergency.

The agencies relating to the efficient functioning of a program of medical education

under these stringencies not only include the various divisions of the health professions themselves but also reach into the national arena touching organizations such as the Health Resources Advisory Committee of the Office of Defense Mobilization, the Selective Service, the Federal Civil Defense Administration and the Department of Defense. A plan to be effective should be coordinated with all these agencies. This in itself is by no means a simple task.

THE MEDICAL STUDENT

Medical education does not commence with entrance into medical school, and thus any plan to insure an adequate supply of medical students should give consideration to the draft-vulnerable college student. In the event of an emergency prearranged plans should go into effect immediately, establishing a national quota of premedical students. The medical schools of this country have a total freshman class of approximately 7,300 students, and using a minimal ratio of two available for each selection this would require an annual quota of around 15,000 premedical students. Those who were unable to matriculate in medicine could be salvaged for training in the paramedical sciences.

The actual selection of the individual premedical student should be the responsibility of the college faculties or joint committees composed of representation from the college and the school of medicine rather than the responsibility of governmental boards or the Armed Forces. As long as grade averages considered to be adequate are maintained, these students should be permitted to continue their studies for not less than two college years, at which time their applications to medical schools should be passed on by the established admissions committees of the individual schools rather than by any state or federal agency.

A standard and uniform plan covering the relationship of the medical student to the Armed Forces should be established. Obviously, the medical student in good standing should be permitted the uninterrupted completion of his undergraduate training which on the basis of an accelerated program would be of approximately three years' duration. In the face of varying degrees of governmental subsidization the exact obligations of the student should be spelled out clearly in order to obviate a repetition of the misunderstanding associated with the A.S.T. and V-12 programs of the last war.

In October, 1946, the Committee on the Training and Supply of Doctors in the Event of Another War reported to its parent organization, the Association of American Medical Colleges, as follows [1]: "Enroll fit medical students in the Enlisted Reserve Corps and then place them on inactive duty status. Students failing to do satisfactory work could be activated and sent to duty. In this way, the Armed Forces would have their doctors; the schools would have 'civilian' students; none could say the students were draft dodgers." This student status the Committee recommended if combined with a policy of governmental loan funds and allotment of books for the needy, plus a special enlisted reserve corps insignia.

Actually there is little reason why the medical student should not continue in the same civilian status as he did in his college years. Such an arrangement not only would relieve the individual student, engaged as he is in an accelerated program, of unnecessary pressures but also would mitigate the time and expense of the red tape involving both the school of medicine and the Armed Forces. In any future total war under the stringencies of universal regimentation the stigma of civilian status may well become obsolete.

The effects of poor judgment and planning in medical education at a national level are demonstrated in the current status of the health professions in Germany. In 1945 the United States War Department prepared a document [2] entitled "The Effect of Bombing on Health and Medical Care in Germany," and in the chapter on medical education may be found the key to an understanding of the tragic aftermath of war in that nation. The document portrays the incessant conflict during the war between the increasing manpower needs for the Armed Forces and the necessity of training physicians both for military service and for civilian practice. The article goes on to say that all students of medicine were called into service at the beginning of the war in 1939, but after the successful Polish campaign those who had completed at least one semester of medical study were permitted to return to their schooling. In 1943 an edict was issued closing all medical schools, and as a commentary on the status of higher education in general

at this time, 60 per cent of the total university enrolment was engaged in the study of the medical sciences.

The medical educators pleaded with Goebbels and others responsible for the directive to reconsider their actions, and as a result a compromise was reached whereby the fourth, ninth and tenth semester students were admitted to medical facilities during the winter of 1944–1945, thus retaining less than one-half of the original enrolment. Not only were there drastic quantitative reductions in the health professions field of education but also, with lectures thrice given and laboratory work by demonstration only, the quality of instruction left much to be desired. This evidence focuses on the dire consequences of the shortsightedness and lack of planning on the part of a nation which in the past had been recognized as the very epitome of precision and scientific acumen.

The manpower demands of a total war should not be permitted to compromise the continuation of an adequate graduate training program, both basic science and clinical. All medical school graduates should be required to undergo an internship, and on completion of this year, one-third of the group should be selected for residency training. Such a selective course will maintain a continuing flow of essential specialists.

THE FACULTY

Most professional communities, embracing within their environs a school of medicine, felt the post-war bitterness engendered by the cleavage created between those who served in uniform and those who did not. There were accusations, justly and unjustly voiced, that the schools of medicine offered a sanctuary to many whose qualifications and past performances did not warrant an "essential" designation. While in certain cases there was a degree of truth to these accusations, on the other hand there were many who, against their own wishes and at the insistence of their superiors, performed invaluable civilian services to the cause of medical education.

It is predicted that in a future total war, with destruction by the enemy reaching into every corner of our nation, the civilian population numerically will suffer far greater casualties than the military. As some would-be prophet has said, probably with a greater accuracy than he himself may have realized, "In the next war the safest place to be will be in uniform." In any event, future international conflicts will see far less distinction between those who serve in the Armed Forces and those who do not.

Plans for medical education in such a national emergency should give serious consideration to the conservation of faculty resources, for wastage in this essential area will result in irretrievable losses to the nation's total health status. In the interests of an objective and dispassionate evaluation of the needs of manpower in medical education and research, there should be created regional advisory committees composed of representatives from the educational and research disciplines to counsel with the National Advisory Committee to Selective Service in respect to priority demands on the faculty, investigators, residents and medical students. These regional committees would function under the National Advisory Committee, as have state and local advisory committees in the past.

While the geographic area of responsibility envisioned for each Regional Advisory Committee might vary considerably, it would be expected that each unit would encompass several medical schools, with not more than a total of twenty such committees throughout the nation. On the eastern seaboard, for example, an advisory committee might be responsible for only one metropolitan area, whereas in portions of the midwest this responsibility might relate to a composite of several states.

The composition of the Regional Advisory Committee should be limited to members of the educational and research disciplines selected in general from the geographic regions of responsibility but not necessarily limited to medical faculty alone. The faculty of other institutions of higher learning in the area might also qualify for membership. After the National Advisory Committee, preferably in consultation with the Association of American Medical Colleges, has designated the various regional areas, the related schools of medicine, in agreement, would submit to the National Committee for its approval a membership list for the Regional Advisory Committee.

In spite of the dangers involved in the establishment of a plethora of committees there is need at a national level for the correlation of medical educational plans related both to per-

CHART I

MEDICAL MANPOWER ADVISORY COMMITTEES TO SELECTIVE SERVICE

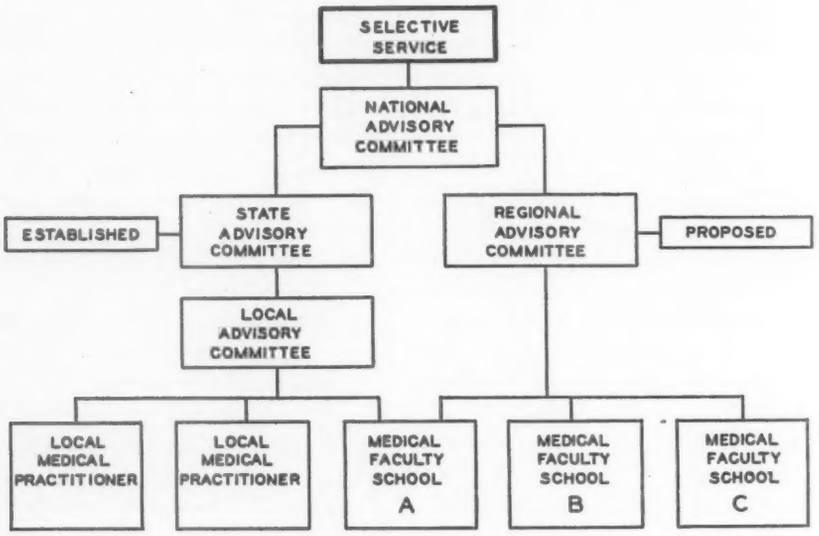
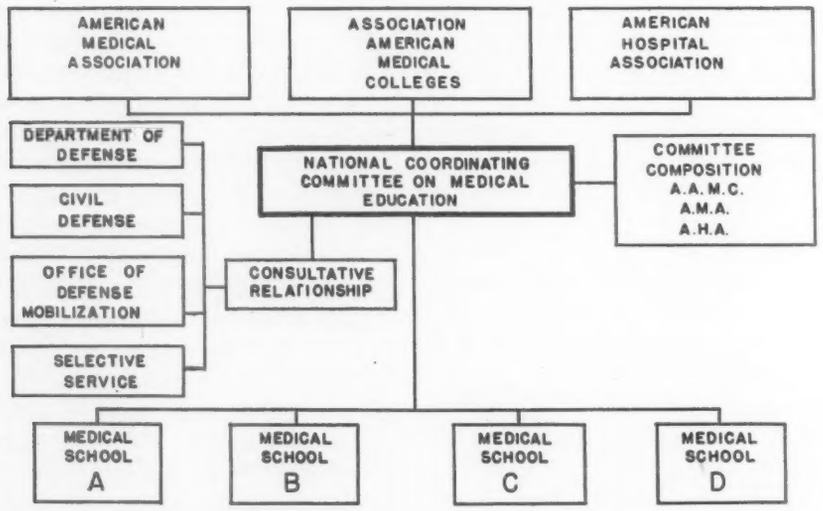


CHART II

THE NATIONAL COORDINATING COMMITTEE

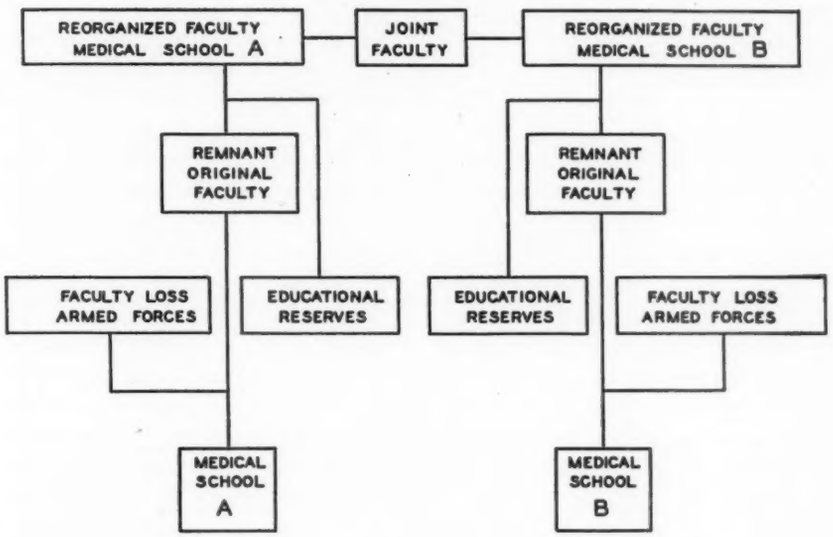


sonnel and facilities. Such a body could be designated the National Coordinating Committee on Medical Education and be composed of representatives from the Committee on Medical Education for National Defense of the Association of American Medical Colleges, the Council on Medical Education and Hospitals of the American Medical Association and the American Hospital Association. The establishment of such a joint committee would in no wise usurp either the authority of the parent organizations or that of the individual medical schools, but rather would place into action a committee with a broad representation well equipped to cope with a wide variety of problems related to medical education in wartime.

The responsibilities of this new joint committee would not conflict with either the function of the Health Resources Advisory Committee of the Office of Defense Mobilization or the National Advisory Committee to Selective Service. The former organization is faced with the problem of the mobilization of the total

CHART III

FACULTY REORGANIZATION IN TIME OF WAR



health resources of the nation in the event of war and the latter is related to the manpower needs of the Armed Forces. (Charts I and II.)

It should not be expected that schools of medicine would maintain a peacetime schedule of action under the pressures of total war. Two factors would increase the teaching and research load of the faculty: first, an acceleration of the medical course, and second, an actual decrease in the available number of faculty. It would be one of the functions of the Regional Advisory Committee in consultation with the National Coordinating Committee on Medical Education to aid in the establishment of staffing criteria which would contribute to a solution of faculty deferment equitable to all schools of medicine. Factors to be considered by the Committee in these decisions should include such matters as the number of medical students enrolled, the responsibility of the faculty for research, faculty obligations for internship and residency programs, the teaching load related to paramedical students and medical technicians, and the adjacency of another medical school.

It is incumbent on each school of medicine to make a faculty survey with frequent revisions in the interest of currency. The initial losses to the Armed Forces by virtue of actual commitments, such as individual active reserve commissions, membership in reserve military hospital units and commissions in the National Guard, may in themselves deplete the faculty ranks to a dangerously low level. How many deans are aware of the total of such commitments among their faculty? When one adds to these losses those due to faculty destruction by enemy action, the seriousness of available teaching personnel resources becomes even more evident.

Having explored the debit side of the faculty ledger, an active survey should be made to determine the availability of local and peripheral physicians and scientists to augment the basic nucleus of faculty in either part-time or full-time capacity. Men and women in this category should be evaluated individually in reference to their particular qualifications. Many retired or semi-retired scientists, both basic scientists and clinicians, might well serve as a valuable educational personnel pool. Such an organization might be designated the "Educational Reserves," having a prior obligation to a particular school of medicine. A central clearing house for personnel of this classification might be established through the auspices of the Regional Advisory Committee and through this Committee coordinated with the various national organizations so that lines of obligation and responsibility would be clearly established. In those medical centers harboring more than one medical school or in plans calling for the emergency relocation of more than one school of medicine in geographic proximity,

mutual programs of faculty sharing should be developed. Adequate exploitation of these possibilities would neutralize to some degree the adverse effect of faculty casualties produced either by enemy action or national priority demands. (Chart III.)

THE FACILITIES

Dr. Hans Reese [2] in a survey made of medical education in Germany immediately following World War II describes the effect of bombing on German universities as follows: "Not only were faculties and student bodies scattered over the country, but more important was the utter destruction from frequent bombings and fires of the institutions, the clinics and laboratories of practically every University surveyed. The continued bombings resulted in an overcrowding in the still existing Universities to a point where instruction was given under severe difficulty. The medical curriculum was adjusted to practical and timely subjects with no opportunity for investigation or research. With the constantly increasing destruction, more and more Universities had to be closed with the consequent overcrowding in the remaining institutions until in March 1945 all educational facilities had succumbed to bombing."

The initial assessment, which will dictate to a considerable degree the formulation of particular plans, is the determination, insofar as possible, of the vulnerability of the individual medical school. Certainly the program envisioned by the University of Missouri, located as it is in a rural area halfway between St. Louis and Kansas City, will be quite different from that of St. Louis University situated in the heart of a metropolitan area. Whereas a considerable portion of the plans of the former institution should incorporate the possible support of medical schools evacuated from St. Louis and Kansas City, the latter school must face the problems of relocation. The determination of target potential priority will not always be as simple as in these cases, and in the face of doubt various alternate plans will be necessary. Those institutions facing a high potential of vulnerability should develop a program of peripheral location and support.

Instructional facilities relate to two rather natural divisions of medical education, the preclinical and the clinical, with the former area incorporating laboratories as well as classrooms and the latter requiring patients and hospital facilities. Although obviously far from ideal, there is every reason to believe that a national emergency in many cases will dictate the geographic separation of the preclinical and clinical years of instruction. Take for example the medical schools in the states of Missouri and Kansas and presume the destruction of St. Louis and Kansas City. The establishment of the preclinical sections of all three displaced schools in Columbia under the sponsorship of the University of Missouri would be feasible. The basic science laboratories could be absorbed not only in part by the medical school but also by an overflow into the University of Missouri as well as other institutions of higher learning in the immediate vicinity.

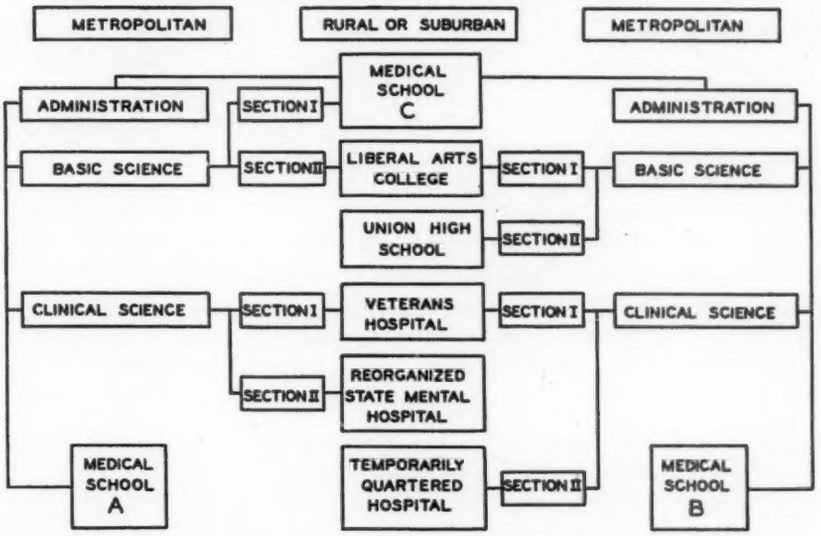
In the struggle for national survival it is unrealistic to assume that for the period of emergency applied research will not replace to a great degree pure or basic research. Although such a situation is far from ideal, depleting as it does the capital investment of basic scientific discoveries without adequate replacement, nevertheless in an environment of war a nation is afforded little choice in this matter. It is to be expected, however, that if basic research can find haven anywhere, it will be within the confines of the medical school.

The hospital facilities at Columbia, Missouri, would be inadequate to support instruction in the clinical sciences for three additional medical schools. Furthermore, under the stringencies of national emergency, insofar as is practicable, clinical instruction must of necessity accept a degree of responsibility in actual patient care. In spite of agreement among medical educators as to the pernicious nature of the practice employed by some hospitals in the exploitation of the intern and resident in the name of education, nevertheless this is a compromise which should be expected under the stress of national emergency. The degree of compromise should be controlled by the actual pressures of demand. Placing the clinical student in the center of increased patient loads also places him in proximity to potential clinical instructors.

The somewhat bizarre distribution of certain Veterans Administration Hospitals, whose location seemingly has been influenced more by political expediency than by practicality, might prove to be a blessing in disguise for the clinical instruction of medical students in wartime. Recently the Committee on Medical

CHART IV

RELOCATION OF DISPLACED GEOGRAPHICALLY RELATED MEDICAL SCHOOLS



Education for National Defense of the Association of American Medical Colleges recommended the establishment of a policy at the national level which would authorize the managers of the Veterans Administration Hospitals to cooperate with the medical schools in planning for potential alternate sites in medical education. (Chart IV.)

One cannot conclude this discussion without reference to the matter of educational and research equipment for the displaced schools of medicine. This relates to such items as textbooks as well as laboratory equipment. In a realistic consideration of the survival of bombed-out medical schools there will be very little left in the way of salvable equipment. In Germany, for example, during the war there was a critical shortage of medical textbooks.

While serving with a guerilla force behind enemy lines during World War II I spent several days inspecting a displaced medical school and found that standard medical texts were rare indeed. Assigned lessons were copied by hand from the one or two faculty-owned, highly prized though antiquated texts for later use in class recitals and discussions. In my possession was a not-too-current issue of *The Journal of the American Medical Association*, which was literally confiscated and then copied from cover to cover, including the advertisements, to be used as supplementary data for faculty lectures and reference material for students.

In spite of the high cost of laboratory equipment and medical literature, the better part of wisdom should dictate the disbursal of basic minimum quantities of these essentials to medical schools located in the more unlikely target areas. It is neither impractical nor impossible to accomplish the microfilming of medical libraries for deposition in safer areas of our nation. With the heavy rural and suburban distribution of high schools and colleges in our nation, surveys of available equipment and space in adjacent school laboratories might resolve certain of the matériel problems facing some of the displaced medical schools. Such equipment and space could be used on a staggered schedule basis.

In the event of widespread physical destruction many individuals will face an economic crisis of grave proportions, precipitated by such factors as the loss of jobs or income property. Such economic pressures may have a serious effect on the medical students directly and on the faculty indirectly. The financial straits of damaged schools, either by virtue of the needs for reconstruction or relocation, may be precarious in the extreme, particularly in reference to privately supported schools. Under circumstances of this nature it is to the best interests of the nation to support financially and otherwise the continuation of medical education. Fundamentally there is no difference whatsoever between governmental subsidization of the private airplane industry in wartime expansion and that of the need for the support

of medical education under similar circumstances. The nation cannot afford the real hazard of even a temporary financial bottleneck in the production of physicians.

SUMMARY

An atomic war, contrary to the majority of current opinions, need not be decisive within a matter of days but actually may be drawn out over years. It is the responsibility of medical educators to plan for such a possibility. Planning must include consideration of both personnel and facilities, with a realistic appraisal of satellite or peripheral support. This involves the evaluation of such pertinent factors as: survey of target potentials; inventory of peripheral facilities, both basic science and clinical; assay of student and faculty resources with consideration of vulnerability from either local or national demands as well as enemy action; and coordination of these plans with relevant authorities.

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The Dallas Tornado Disaster

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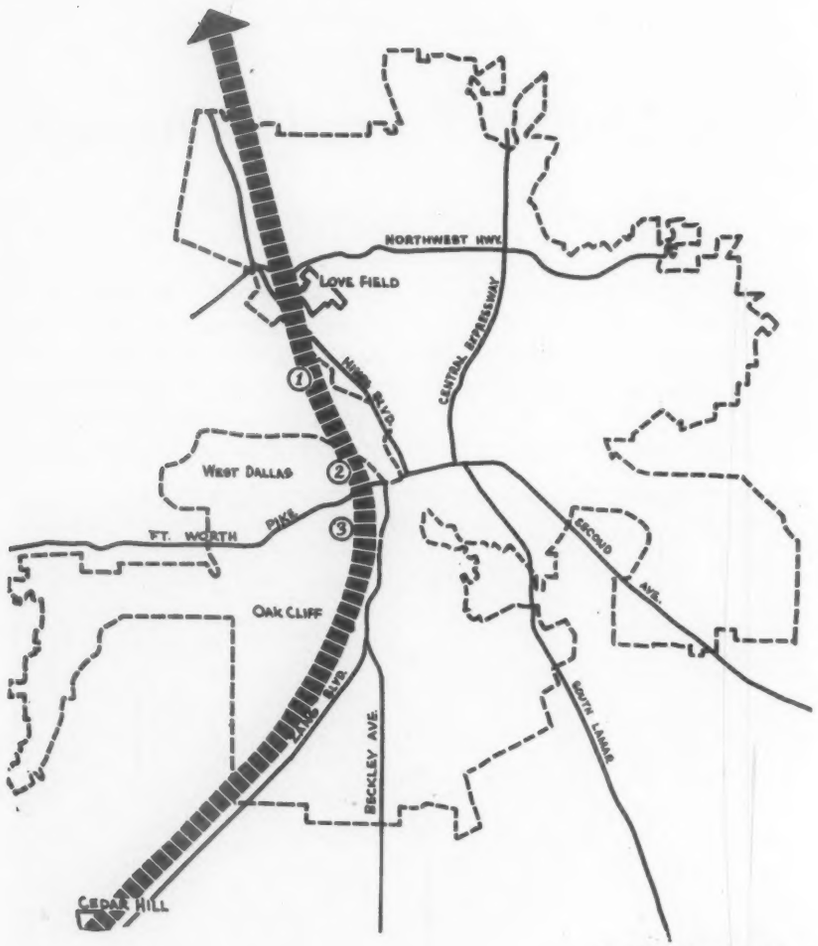
ON April 2, 1957, the north-central area of Texas was in the path of a southeastward-moving low pressure system attended by numerous thunderstorms and tornadoes. One of the earliest tornadoes to develop in the area originated in southwest Dallas at 4:30 P.M. and moved northward across the western section of the city. The tornado, with a forward speed of 25 miles per hour, cut a continuous path about 100 yards wide for approximately 16 miles across the city of Dallas. The rotational direction of the funnel was counterclockwise with resulting explosion when structures were hit and the tossing of pathway fragments 300 or 400 feet into the air. There were ten fatalities and 183 injuries requiring hospital treatment. Property damage was estimated at $4 million, with 574 buildings damaged or destroyed.

Dallas Morning News

FIG. 1.

The general nature of the tornado, for informational purposes, is presented in Figure 1. The tornado swept through its path as defined



Dallas Morning News

FIG. 2.

in Figure 2. It was directly visible throughout its course, a factor which undoubtedly played an important role in avoiding a more extensive number of injuries. Traffic was generally heavy with a good portion of the populace returning home from work. Many children were playing in open areas about their homes and neighborhoods. The traversed portion of the tornado generally involved a good portion of poorly constructed dwellings, many shack structures, and a few commercial and factory units. The frame structures, many of which were in need of extensive repair, crumbled easily under the force of exposure and the loose fragments resulted in much flying debris.

THE DALLAS CIVILIAN DEFENSE PROGRAM

The Dallas Civilian Defense program had been approximately one year in operation. With visualization of the tornado and official notification by the weather bureau, the police, fire and ancillary departments were notified along with civilian defense authorities. The Dallas situation is unique in its communication system in that a central police dispatcher has immediate means of communication with ambulance services and a direct line to the primary disaster hospital in the city, Parkland Memorial Hospital. The police department immediately dispatched a large traffic and control force of officers to the main scenes of the path of the tornado and to the traffic roadways leading to the hospital, as well as to the hospital itself for service and aid. As calls were received by radio and telephone by the police dispatcher, ambulances were dispatched to the scenes of wreckage and possible injury.

The ambulance service in Dallas is organized

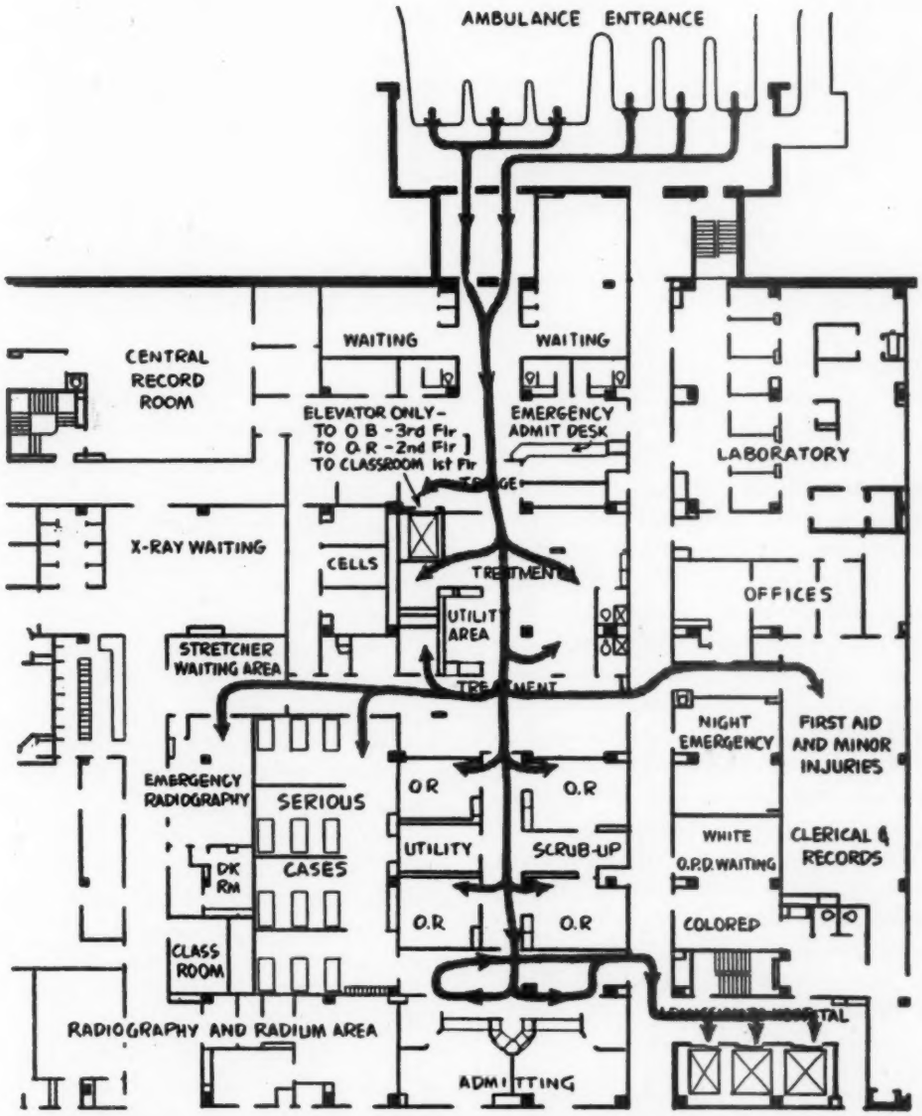


FIG. 3. Diagram of part of the ground floor emergency area where patients were admitted during the tornado. Light gray lines show the traffic flow from the six entrances to the triage section for sorting and from there to first aid, observation, surgical suite or morgue as the individual case required.

so that all major forms of trauma are automatically brought to Parkland Memorial Hospital by ambulance services. The distribution of patients brought to Dallas hospitals is presented in Table 1. The load tolerance for Parkland Memorial Hospital was a joint decision of the triage and control officers of that institution. Patients were accepted as long as it was thought that the total facilities could handle the situation.

TABLE 1
INJURIES REQUIRING HOSPITAL ENTRY

Hospital	No. of Cases
Parkland Memorial Hospital	178
Methodist Hospital	17
Baylor Hospital	2
St. Paul's Hospital	1

The medical aspects of handling trauma cases centered about Parkland Hospital. Parkland Memorial Hospital is a county district institution which serves as the primary hospital

FIG. 4.

for the care of indigents in the area as well as the teaching hospital for the University of Texas Southwestern Medical School. Staff appointments are bilateral. Parkland Memorial Hospital is a new structure completed in 1954 with 600 beds. It has a house staff of approximately 125 members, an attending physician group of 300, 400 available medical students and 200 student nurses as well as 200 graduate nursing personnel. The emergency service treats approximately 200 out-patient emergency cases per day, of which about 30 per cent are instances of trauma. The emergency room area is located on the ground floor and is flanked by the radiology department. Abundant areas exist for conversion to treatment and evaluation areas. These include the clinical laboratory areas, a large stenographic area and long, wide corridors. The basic plan is depicted in Figure 3.

THE PARKLAND MEMORIAL HOSPITAL PLAN FOR DEFENSE

The Parkland Memorial attending staff disaster team was organized two years prior to the tornado incident. It consists of divisions of medical, nursing, laboratory and service personnel into groups for a major and minor disaster. Several preliminary meetings had been held to outline the program. The true value of preliminary planning was not realized until the disaster occurred. Ironically, a boy scout rehearsal was planned to work out some of the unforeseen problems which might arise in case of a major disaster. The tornado offered the entire group a real opportunity (without boy scouts) to evaluate its effectiveness and to achieve orderly performance under stress.

THE SEQUENCE OF EVENTS

The first casualty arrived at the hospital emergency room at approximately 4:50 P.M. At the same time the full complement of the house staff and nursing personnel was on hand. The physician director and assistant director were fortunately on hand at the time. The minor and major disaster teams were notified and the necessary measures were taken to alert all groups involved within the hospital. Employees of all categories from the morning shifts were asked to remain on duty. A triage team consisting of two senior surgical residents and one intern was immediately set up at the emergency room entrance, as well as secretarial personnel for tagging and tally. The director, who also served as supervisory triage officer, worked together with the hospital administrator. As professional personnel arrived at the hospital they were allocated to various divisions for medical care. The director maintained a continuous record of the distribution of medical and nursing personnel allotted to different divisions. Specialized surgeons were assigned to the senior attending surgeon in their category for further assignment and performance. A separate pediatric wing was immediately set up to handle the large number of children who were involved in injury. Arriving pediatricians were assigned to that area. Likewise, the director assumed authority for all initial disposition of medical and nursing personnel within the hospital. The basic triage system that was adopted followed the schedule in Figure 4. A dry run of the plan had been executed one week before the tornado disaster occurred. It proved invaluable.

The timing of events relative to admission, disposition, surgery and discharge is diagrammed as follows:

Time	*Event*
4:50 P.M.	First casualty admitted. Disaster teams notified. Area directors assigned with ancillary personnel.
6:10 P.M.	First major operation begun (amputation of right leg). Call for blood donors over local radio and television.
7:10 P.M.	Sixty casualties admitted to the various hospital areas for evaluation and treatment. Full complement of personnel available on duty.
9:10 P.M.	One hundred thirty-nine casualties admitted by this time.
11:10 P.M.	A total of 178 patients admitted.
11:30 P.M.	Eighteen major operating room procedures completed. (Sixteen elective surgery cases had been completed before the disaster struck. Elective surgery was resumed on Thursday, April 4th.)
12:00 A.M.	One hundred four of the 178 patients admitted were discharged; seventy-four patients remained.
6:00 A.M.	Thirty-three patients remaining in the hospital for further treatment; 192 pints of blood collected. (Tables II and III.)

TABLE II
DISTRIBUTION OF SERIOUS INJURIES

Trauma	No.
Injury to head	7
Extensive lacerations	9
Fractures	14
Injury to chest	2
Total	32

TABLE III
PARKLAND MEMORIAL HOSPITAL DISASTER VICTIMS

Total patients treated	178
Total admissions	74
Admissions beyond 24 hr	33

COMMENTS

A well organized hospital disaster plan must have certain basic requirements for smooth and adequate functioning. These are: (1) suitable architectural design and construction, (2) adequately trained personnel, (3) an integrated administrative body, and (4) an over-all disaster program which functions as a team of group units.

The Parkland Memorial Hospital disaster program functioned as well as it did during the tornado disaster because the over-all picture well embodies the principles already outlined. The Hospital Planning Board inaugurated facilities within the new structure which are essential to handling a major natural or industrial disaster. The abundance of space available throughout the emergency room area and its adjourning suites make conversion to facilities to handle disaster simple and direct. Parkland Memorial Hospital represents an ideal and model institution in that its construction affords great versatility for expeditious conversion.

The success and speed with which the Parkland Memorial Hospital house and attending staff handled the tornado disaster is a tribute to their knowledge and ability. At times it appeared that the casualties were just part of the routine patient load admitted and treated in the emergency room. Rapid medical evaluation comes easy to a house staff in a combined county and teaching institution. The surgical teaching program has always embodied the important principles of the early recognition and treatment of the shock state, fluid and electrolyte balance and a "do it yourself," approach toward the care of the injured. During no period of the disaster was there any neglect of the ill, or faltering medical steps taken by those who attended the injured. The student and graduate nurses also demonstrated an eager, though disciplined and capable talent in doing a job well.

One important factor responsible for the success of any hospital disaster program is an able and integrated administrative body. The hospital administrator and his staff at Parkland Memorial Hospital assumed most important roles during the tornado disaster. He expedited the requests of the director and guided many of his decisions concerning ward and bed relocations, Red Cross activities and hospital housekeeping. He also served as public relations officer for the hospital and police liaison officer. The administrative body of the disaster team has been an important stimulus to many a heretofore indifferent medical group concerning

the problems which might arise when mass casualties occur in the area served by the institution.

There is little doubt that the orderly care of the disaster victims at Parkland Memorial Hospital would have been complete confusion had not previous planning and thought been conducted by the senior departmental sections of the disaster teams. The dry run meeting previously conducted by the disaster group at Parkland Memorial Hospital did not generate much enthusiasm, although basic interest existed. The formulization of a disaster plan requires a good deal of imagination and detailing of unforeseeable events. Apathy may initially obtain in a group—much like illness which only invokes sympathy in those of immediate concern. Nevertheless, a well organized and interwoven disaster plan is of paramount importance and should be of vital concern to all. The success and ease with which the Parkland Memorial Hospital group handled the injured tornado victims is a potent argument and realization that disaster planning is absolutely essential. It is hoped that the experiences of the group in Dallas will serve as a stimulus for many hospital community disaster programs, and will further interest national concern for civilian defense and disaster organization.

SUMMARY AND CONCLUSION

1. The salient factors relative to the Dallas tornado of April 2, 1957, are presented.

2. One hundred eighty-three injuries and ten deaths resulted from the disaster.

3. A brief summary of sequential events depicting the disaster team and plan at Parkland Memorial Hospital is presented. All concerned believe the success in handling 178 cases treated was due to previous disaster planning.

4. The principles of disaster planning adopted by the Parkland Memorial Hospital team are presented with the hope that it may serve as a stimulus for national civilian defense programs and disaster conferences.

The Speeding Ambulance

GEORGE J. CURRY, M.D. AND SYDNEY N. LYTTLE, M.D., *Flint, Michigan*

From the Section for the Surgery of Trauma, Hurley Hospital, Flint, Michigan.

DURING the past few years considerable criticism has been directed toward the speeding ambulance. Opinions have been expressed by various groups regarding the necessity of speed in transporting the injured. The general impression among lay people is that speed is necessary in saving lives. The opposite view is expressed by some members of the medical profession, who believe that sirens should be removed from the ambulances, and all traffic and speed regulations should be obeyed even to the point of waiting for red lights. The proper approach to this problem may lie somewhere between these two extremes.

An ambulance averaging 30 miles per hour would require ten minutes to travel 5 miles. To save five minutes, 60 miles per hour would be necessary. In 2,500 consecutive ambulance runs, this time interval would not have influenced the course of a single injury.

Time trials under different traffic conditions were carried out over a 4.4 mile stretch of a usual ambulance route. An ambulance with the right of way should be able to travel this distance in less than ten minutes without speeding. The shortest trial, obeying all traffic laws, was thirteen minutes; the longest was twenty-eight minutes. When this delay is added to that necessary for the ambulance to reach the accident scene, the travel time may become significant.

In this series of 2,500 consecutive ambulance runs there was only one case in which a moderate delay in transportation could have resulted in death. This was a four year old child who had sustained an open wound of the neck when she was thrown against a gear shift lever. This accident produced fractures of the voice box, the upper end of the trachea and bilateral pneumothoraces. Prompt measures restored her vital capacity and she survived. The total elapse of time between the dispatch of the ambulance and her arrival at the emergency receiving department was twelve minutes. The accident occurred a little over a mile from the hospital, and transportation was accomplished without excessive speed. Had the transportation time been increased by many minutes, it is probable that this child would have died.

Of the 2,500 cases, twenty-seven persons were dead on arrival. Five of these died of fracture-dislocations of the cervical spine with complete transection of the cord above the fourth cervical vertebra. Twenty persons died of severe craniocerebral, chest and internal injuries. There was one case of strangulation by hanging and one of drowning. None of these persons could have been saved by a speeding ambulance.

Thirteen persons died in the emergency receiving department. These persons apparently died from injuries to the head and chest, although other multiple injuries were present.

Postmortem examinations performed on those who died of severe injuries to the chest revealed combinations of rupture of the diaphragm, fractures of the liver and spleen, and lacerations of the aorta, inferior vena cava and the heart. Those not autopsied presented external evidence of severe injury.

It is believed that none of these victims, who were dead on arrival or who died in the receiving department, would have survived even if the injuries had occurred on the hospital doorstep.

In only forty-five instances was the time interval between that of the accident and the arrival at the hospital considered to be significant as far as the patient's course was concerned. Expeditious handling of these victims was desirable, but the speeding ambulance was considered unnecessary. In nine of these accident victims a wild, weaving, siren-screeching ride to the hospital might have produced death or permanent invalidism. These included seven

cases of multiple rib fractures associated with unstable rib cages and pneumothoraces, and two fracture-dislocations of the cervical spine.

The other thirty-six victims were in severe states of shock at the time of their arrival at the hospital. The shock was produced by fractures of the liver and spleen in five cases, multiple fractures of the skeletal system in eighteen, superficial lacerations in eight, penetrating wounds of the abdomen and chest in four, and one burn. The degree of shock in any of these cases might have been increased by a rough ride in an ambulance.

In this series of 2,500 consecutive ambulance runs, haste in transporting the injured was unnecessary in 98.2 per cent. There would have been no difference in the outcome of 2,455 patients had they been transported according to the standard traffic regulations.

In 1.8 per cent expeditious handling was considered necessary, but a speeding ambulance could have increased the severity of the injuries.

It is recommended that:

1. Ambulances in transporting the injured person should observe the local speed laws of the vicinity in which they are traveling.
2. They should retain the use of their sirens.
3. They should have the right of way in traffic.

Panic by the uninformed is behind the widely held fallacy that speed in getting the accident victim to the hospital is all important. Prompt immediate care may be vital, but speed merely increases the accident hazard.

DISCUSSION OF PAPERS BY DRS. CASBERG; FOGELMAN; AND CURRY AND LYTTLE

ROSWELL K. BROWN (Buffalo, N. Y.): I cannot say that I enjoyed your fine presentation, Dr. Casberg. It was a painful experience for me but, I trust, beneficial.

We have a Buffalo Plan which was made without great consultation, because the Dean just recently assigned me the task. It involves three possibilities:

One is to move to the Veterans Hospital facilities in Batavia some 40 miles away and use the adjacent public schools. The facilities would be inadequate.

The second is to move to the Chautauqua Institution and take over the hotels and concert halls, etc. That would be very inadequate but it could be used. It would be better than tents.

The third plan seems more workable to us. That would be to go as a body of refugees, faculty, students and perhaps even patients to one of the adjacent medical schools (Toronto, Rochester, Cleveland, Syracuse or Pittsburgh) and use, by prearrangement, their facilities in off hours, weekends and nighttime. We think that by combining forces in that way we might carry on education without loss, perhaps even in some areas with improvement.

However, that plan is what I might consider a worm's eye view of the situation as compared with Dr. Casberg's eagle's eye view. That plan has not been approved by the faculty, the executive committee, civilian defense, the military, the government or anyone. A plan of that sort, to be effective, must be generally understood and worked out, and not just be the opinion of a few. I would like to ask Dr. Casberg how we can proceed toward a realistic plan.

My second question has to do with separation of the medical schools into clinical and preclinical in time of disaster, as suggested by Dr. Casberg. It would be hard enough without arbitrary division. It seems that evacuation on a warning alert (that is, before the catastrophe) is unwise, because minimum enemy action might result in total confusion and our defeat. Hence we believe our plan should focus attention on the zone of partial destruction about the catastrophe. Those in this zone may not even know how big the catastrophe is; all they would know is that in one direction there is destruction and in the other direction there may be safety. The phenomena of rushing people out of the zone of partial destruction and then rushing back in are well known. We should make our plans in accordance with these movements and not try to control them.

Can we not, then, keep our medical school together as one within the zone in which the rest of the population in this area will naturally be moving?

A third question: Since the difference in military and civilian medicine is going to disappear and since our previous military organization will not be adequate in that it is directed toward an expeditionary force—all our wars have been overseas and it seems this one is going to be in the homeland—should we not right now, in peacetime, be making some vertical integration and unification of teaching services in civilian medicine and the Armed Services?

WARREN H. COLE (Chicago, Ill.): All three of these papers are extremely interesting and valuable. However, I will confine my remarks to Dr. Fogelman's paper, since he asked me to comment on his.

I think all of us will agree that the injuries sustained in a hurricane are of a unique and strange type. Those of us who have had experience with hurricanes never will forget that catastrophe. My only contact with a hurricane was about twenty-

seven years ago but I remember some of the injured people as vividly as if they had come to my attention just yesterday.

For example, one of these patients had a portion of a plank 1 inch by 3 inches by 2 feet driven through the abdominal wall. He was a fat man, weighing about 300 pounds, and, believe it or not, the plank had been sawed off by the first aid workers; he arrived in the hospital with it still in his abdominal wall. However, the injury inside the abdomen was not fatal. I should add that these patients came to us in St. Louis (while I was working in Barnes Hospital) by train, from Murphysboro, Illinois. About seventy-five or eighty of the seriously injured arrived at one time.

Another patient said he regained consciousness and looked up to find his neighbor's stove lying on top of him.

Another patient, a farmer, was walking to his house from the barn, saw the hurricane coming and grabbed the base of a tree. When he regained consciousness he was out in the field a half mile away, still hanging on to the trunk of the tree.

Another patient had a straw driven through the soft tissues of the arm; the straw was left in place by the first aid personnel working at the scene of the hurricane.

I do not know whether or not Dr. Fogelman had such strange cases. I am sure he did have but that he did not have time to talk about them. However, I did want to ask him about tetanus and gangrene.

Did you have any cases of either, Dr. Fogelman? If so, what was the result?

I was delighted to hear Drs. Lyttle and Curry's paper because I have always believed ambulances do not need to drive down the street at a speed of 60 miles per hour because they may do more harm than good by such rapid transit. In the first place, the patient himself may be injured by the rough ride, but in the second place, pedestrians may be injured and other automobiles damaged. I think Dr. Curry told me there were two serious accidents. Is that right, Dr. Lyttle?

DONALD M. GLOVER (Cleveland, Ohio): I would like to speak mainly to make a brief comment on one problem in relation to Dr. Casberg's excellent presentation. That has to do with not only the planning for medical school facilities in time of disaster, which strikes the area in which the medical school is located, but also the distribution and rotation of personnel in the event of long absence from the home site of part of the faculty of the medical school. Those of us who still have rather vivid memories of the situation during the last war and the previous war, when most of the fighting was done elsewhere, fortunately, know the problems of having a portion of the faculty away for what seems like many years. It demoralizes both the local faculty and, certainly, that portion of the faculty which is overseas for three or four years. This is a very serious and difficult problem from the standpoint of the Department of Defense, we all know. But it seems definite that, along the lines of Dr. Casberg's remarks, some sort of definitive planning needs to be made, not only from the standpoint of defense and protection of our medical teaching faculty when they may be attacked at home, but also when it is necessary to disperse personnel to other areas. Some method of rotation should be devised in order to avoid the inevitable demoralization that results from the programs followed in previous wars.

It is very reassuring to hear Dr. Fogelman say that the effort for defense planning, civilian defense, really pays off. It is pleasant for some of us who have struggled with local apathy to find that it really does help when there are adequate plans for handling mass casualties.

Together with others, I congratulate Drs. Lyttle and Curry on presenting factual evidence that speeding ambulances are unnecessary.

JAMES H. SPENCER (Newton, N. J.): Drs. Lyttle and Curry can be classed as evangelists. I do not know whether George will object to being in that category or not, but I understand that when Billy Graham puts on a show, if you want to call it that—I like to think of it as something different—many people are inspired to go back to their communities and spread the gospel that he has preached.

These three papers are non-scientific but I think they are more important, probably, than some of the scientific discussions which will follow. However, the papers will do no good unless we carry their evangelistic message back to our communities. I remember about thirty years ago, when I taught anatomy for two years in Memphis, that ambulances used to travel at about 90 miles per hour until somebody was killed. Then the newspaper editors took over and the ambulances began to obey the speed limit.

I have done this once in my community. We had a man admitted to our hospital just a few months ago, and one of our nurses reported to me that she saw the ambulance go by at 80 or 90 miles an hour. That started my adrenalin to flow and I investigated the situation. I talked to the doctor who sent the patient in; I talked to several of the people who had witnessed it. The doctor said that he had told the ambulance driver to take it easy because the patient had a bad cardiac condition. I found out from the special nurse, whom I knew very well, that the patient was so frightened that she was surprised he wasn't dead on arrival.

Well, I called up our local newspaper editor and told him the story. He reminded me that we had to use care not to hurt the feelings of the volunteer ambulance drivers. And that is true. They deserve a lot of credit, but they think that we doctors want

the patient moved in a hurry so we can start treatment.

The editor waited about two weeks until things calmed down a bit and then wrote a very creditable editorial in which he did not condemn the ambulance drivers, who were the people at fault in this case, but said that we must not demand of the ambulance drivers speed. I think it was put tactfully and it has done a lot of good. We have had no sirens blowing in our community since, and that was last June.

I think if these papers, particularly Drs. Lyttle and Curry's, are going to do any good, we have got to take their message back to our communities. Each one of us has got to believe that he must pass this on to the place where it will do the most good.

PRESTON A. WADE (New York, N. Y.): I have enjoyed all three of these papers. As Dr. Spencer said, it is a very valuable lesson for us to take home.

I will confine my remarks to the last paper. Drs. Curry and Lyttle have certainly given us documentary evidence that we can use to make rules and regulations and see that they are enforced. I think there is one thing they did not include in their series of casualties, and that is the casualties to the doctors or other people riding the ambulances.

I rode a thousand calls while at New York Hospital in 1925, and in not a single one of those cases was it necessary to hurry; yet the ambulance driver and I both had much fun going as fast as we could go, even coming back from a case when we had nothing to do. The thrill of driving in a fast car is exciting, and that is one situation in which we need the rules. It was not until one of my classmates and best friend was killed in a Bellevue ambulance accident that I realized the foolishness of this.

We have had many of our interns injured in ambulances. That is merely another reason.

I think this discussion gives us something to take to the people who are in charge of the ambulance drivers, and I think that Dr. Hampton and his Committee on Transportation of the Trauma Committee can circulate this résumé or summary of the facts to the various communities in the hope that it will help to establish some rules and regulations.

The private ambulances are hard to control. Those persons who are volunteers many times take the jobs and use the ambulances for the fun of it, for the thrill that goes along with the pleasure of driving fast. Unless we can make these drivers slow down with something like this, we cannot do anything about it. I think this last paper is invaluable and may help in transportation of the injured.

DOCTOR GEORGE EHALT (Graz, Austria): I might add a few words from our experience in peacetime, and especially during the war period. We had an organization spread all over the country which included all parts, not only medical but also the military, the police and the boy and girl scouts. We got our experience, fortunately or unfortunately, however you would call it, from the war. In the last months we had, five days a week, as many cases coming in as you had during the Texas disaster in one day. We made our own organization at this time and we had to do it under very poor conditions.

Finally, sometimes we had no electricity or water. We could not even use ether, so we had to go back to the old chloroform. We found that the organization in the hospital itself was the best. The doctors found the best way was to organize it. It meant that the doctor had to classify the cases. He had to determine who would die, or say, "This is unimportant; he can wait," and "The others have to start right away to have work done." All people were specialized. One had to do the amputations. The nurse gave the serum. Another administered the morphine or a patient had to be catheterized. We indicated this on the patient, either on a piece of paper or his skin if possible. This was done to avoid having three or four people treat one patient and neglect another.

Now, I have one question for Dr. Lyttle. There is a movement in Europe especially promoted by Professor Kirschbauer from Heidelberg to bring the operating theater to the place of the disaster or catastrophe. I do not think it is necessary or good, especially after what I have heard from Dr. Lyttle, but we found it important to bring the shock treatment to the place of the accident, even the smaller accidents, involving two, three or four patients. It would be interesting to know Dr. Lyttle's opinion about this point.

CHARLES G. JOHNSTON (Detroit, Mich.): I would like to mention, in relation to Dr. Curry's paper, that the Flint group has been very active in studies of the transportation of the injured. This problem of the speeding ambulance is one which has come to everyone's attention. I am pleased to hear the rather broad recommendations that were made, which will leave the problem in the hands of those who are driving the ambulances. If they are trained, as they are in Flint, I suspect that they have some notion of when they should hurry.

Some time ago at our hospital they put governors on our ambulances for a short time and it was a rather bad thing to do. I think the business of putting a governor on an ambulance is a governor misplaced. The governor, of course, as Dr. Wade has indicated, should be placed upon those running the ambulances.

MELVIN A. CASBERG (closing): In reply to the question raised by Dr. Brown—what should be done to correlate this type of planning on a national

scale?—I might say that such action has been initiated.

At the annual meeting of the Association of American Medical Colleges recently held in Atlantic City the Committee on Medical Education for National Defense recommended that the Association request each member school of medicine to develop plans and alternate plans for action in the event of national disaster.

Dr. Brown questioned the necessity for the separation of the clinical and premedical sections of a medical school under an emergency environment. Where such cleavage is not necessary, obviously, it should not be done, for a dichotomy of this nature does not lend itself to good pedagogy. However, in my personal opinion, the majority of schools will be forced into this separation merely by virtue of the dislocation of teachers, students and patients.

Your suggestion, Dr. Brown, that plans of the medical schools be correlated wherever possible with those of the medical departments of the Armed Forces is well taken. Such an interrelationship would prove to be most important.

The purpose of presenting this paper was neither to offer a completed and perfected program nor to answer all questions, but rather to stimulate serious thought.

As to the comment made by Dr. Glover in which he suggests a rotation of billets between the more desirable and less desirable assignments, I was overseas during World War II for almost three years myself, so I think I know something of his thoughts on this matter. This particular facet of the problem might well be handled through policies established by the National Coordinating Committee on Medical Education which I discussed in the paper.

MORRIS J. FOGELMAN (closing): I want to thank Drs. Cole, Glover and Spencer for their remarks. A good number of human and professional interest stories certainly develop about any disaster.

One concerns a young housewife who was on her way to our hospital at the time of the disaster when she was knocked down and bruised by much falling debris. She was brought by ambulance to the emergency room and put into the flow plan of the disaster. Following x-rays and suture of multiple lacerations we discovered that her real trouble had nothing to do with the incident at all. She had an ectopic pregnancy, tubal, which was removed about one hour later.

To answer Dr. Cole's question regarding tetanus and gangrene, we had no cases, and because of the present time limitation I shall not comment further on any of our routines in this regard.

SYDNEY N. LYTTLE (closing): I wish to thank the discussers of our paper. In answer to Dr. Cole's question regarding injuries to pedestrians, approximately ten years ago, before we clamped down on the speed of ambulances in Flint, within a two-week period there were a number of such cases. One ambulance was going at an estimated 70 miles an hour speed and collided with a truck. The ambulance attendant was killed.

About two weeks later another ambulance, going about the same rate of speed, collided with a convertible, killing the ambulance attendant and the driver of the convertible. That accident caused the institution of the present system in Flint, consisting of a central dispatching agency for the ambulances which are mostly private concerns owned by morticians and a few independent ambulance companies. These are dispatched by the Police Department to the scene of the accident. The speed limit on them now in Flint is a top of 35 miles per hour. They still have the right of way in traffic.

During the past five years there have been six accidents involving ambulances. None of these has resulted in injuries; most of them have been of the fender dent variety.

In answer to Dr. Ehalt's question regarding the taking of emergency care to the patient, the ambulance drivers in Flint are certified as to their proficiency in handling the injured. They have completed Red Cross courses in first aid, and they have received instruction from the members of the Committee on Trauma of Flint regarding the handling of these accident victims. We do not have a doctor ride the ambulance. However, at the scene of the accident these patients are examined well by the ambulance attendants. Fractures are splinted and necessary first aid measures are carried out. The time of getting these patients into the hospital is relatively short and we do not believe it advisable to insist on a physician being present at the scene of the accident.

Sutures for Trauma

J. W. Blunt, Jr., M.D., *Cleveland, Ohio*

From the Claud Foster Laboratories of the Department of Surgical Research and Division of Surgery, Saint Luke's Hospital, Cleveland, Ohio.

How do you know, when you request a specific type and size of suture for suturing a lacerated tendon, a divided vessel or a severed nerve, that you are going to get what you request? You know because there are, in the United States Pharmacopeia [1], some well defined standards and tests to which all non-absorbable surgical sutures must conform before being marketed for the surgical profession in the United States. The agency which assures that these standards will be followed is the Food and Drug Administration of the Department of Commerce. This report will cover the findings on silk sutures, but other materials such as cotton, linen, nylon and PETP* will be included when there has been sufficient experience to warrant. The absorbable surgical sutures and wire sutures are the subjects of other reports [2] and will not be included herein.

Since the U.S.P. requirements for sutures are based on manufacturers' standards, and not surgical standards, attempts will be made to point out some of these lacks and how they may affect the critical use of these materials in the most exacting of suture requirements, the surgery of trauma. The purpose of this paper is not to give the details of the individual technic nor in any way to attempt to tell surgeons how to use the sutures, but rather to indicate the present findings on the physical and biological properties of these sutures.

MATERIALS AND METHODS

The sutures were purchased on the open market, from five of the major suture-manufacturing houses. The diameters of the sutures were checked with a standard footplate, dead-weight gauge, and by micrometer readings under a microscope. The tensile strengths were determined on a Scott Inclined Plane Tester. Biological testing was done by implanting the sutures in musculofascial tissues of rats, taking specimens at intervals of three weeks, six weeks, three months and six months. These periods had been determined by previous investigations to give a good index of the tissue reaction to the test material [3].

DIAMETER

According to the present U.S.P. standards, the diameter of the suture is measured in three separate areas along its length, using a dead-weight gauge. The load applied by the presser foot is 210 gm. In other words, the suture material is compressed between two metal parts by a 210 gm. weight and the remaining diameter is recorded. There is an additional requirement that during the measurement the suture should be under a tension equal to one-quarter of its tensile strength. Using this procedure, all sutures fell within the U.S.P. stated limitations of suture diameter.

However, it is apparent that at no time during surgical use of the suture materials is there a 210 gm. metal weight compressing it, nor is there a drag through the tissues equal to one-quarter the tensile strength of the suture. This may be of significance in such work as suturing blood vessels where a uniform diameter of suture material is important for a successful non-leaking anastomosis. Those materials that are braided are particularly prone to have a lack of uniformity in their diameter unless they are placed under tension. Many of these materials are packaged either over a reel or in glass tubes which sharply bend them at even areas along their length. Where the braided material is in contact with the reel or is acutely bent, it tends to

* Polyethylene terephthalate, sold under trade names of Terilene and Dacron.

flatten out; since it is sterilized in this position, it maintains that flattened state until tension is applied. If a No. 3-0 suture is used, there are regularly spaced nodules with effective diameters of a No. 2 silk suture. When the suture is pulled up and the anastomosis completed, the hole that was made by the No. 2 suture is being filled by the No. 3-0 suture, leaving a leaky dike. If the diameter of the tensed suture is read through a microscope, using a micrometer eyepiece, the diameter of the suture averages two sizes larger than the size stated on the label. This is because there is no presser foot compressing the suture material. It would be clearer and more factual to establish the standard for suture diameter on readings made through the measuring microscope, of sutures that are under tension equal to the "drag of the tissues."

TENSILE STRENGTH

Breathed there ever a suture salesman who did not state that his company's sutures were the strongest? With the exception of repair of tendons, the actual strength of the suture material is of relatively little importance because the tissues will tear through long before the suture breaks. However, it is a convenient measurement and there has to be a certain baseline requirement or we would find all ranges of strengths for different diameters. The U.S.P. standards use the tensile strength as a convenient measure of this suture property. Tensile strength is defined as "the maximum tensile stress expressed in force per unit area of the specimen at the time of rupture" [4]. All sutures were within the U.S.P. prescribed limits for tensile strength. Unfortunately, numerous difficulties were encountered. The first was that the technic for making this measurement uses the metric system, while the standards are given in the avoirdupois system [1]. The second problem was that the U.S.P. test prescribes that the tensile strength shall be measured on the suture, immediately after removal from the sterile container, while sutures that come on bulk spools have to be brought to 65 per cent relative humidity before testing. Since the surgical application of these non-absorbable sutures is always in a relative humidity of 100 per cent, repeat tensile strengths were tested after the sutures has been incubated in normal saline at body temperature for one to three hours. The surgical silk from all manufacturers averaged a loss in tensile strength of 25 per cent after incubating at 100 per cent relative humidity. Since it is the strength of the suture a few hours after it has been inserted that is surgically important, when the patient is in the recovery room regaining consciousness and putting a maximum uncontrolled stress on the suture material, I suggest that the standard for these sutures should be prescribed at 100 per cent relative humidity or after being in an animal for five days. It was of interest to note that cotton, linen and the other plastics, with the exception of nylon, showed relatively less loss of strength, approximately 5 per cent following the incubation at 100 per cent humidity. Nylon was in the range of 10 per cent loss following incubation for one to three hours.

The tensile strength is only part of the problem. The major surgical property is the knot strength of the suture. The U.S.P. gives the technic for doing the knot strength test, but records no standards for this important property. In our tests the knot strength averaged one-half of the tensile strength of the suture in all diameters. In actuality, the tensile strength of the suture is not the important property because it is dependent on the cross sectional area of the material. The breaking strength is the specification which most interests the surgeon as it is not dependent on the diameter. The breaking strength is what the surgeon tests when he ties the suture or ligates the vessel.

COATINGS

In the U.S.P. description of the non-absorbable sutures there is a sentence which reads as follows: "It may be coated or uncoated, and may either be untreated for reduction of capillarity and designated as Type A, Untreated or Capillary, or be treated to reduce capillarity and designated as Type B, Treated or Non-capillary." There are no limitations or prescriptions given in the U.S.P. for the coating material. Most of the suture manufacturers have their own formula for this coating material. For the most part these coatings are composed of oils and waxes, some of which have high melting points to resist removal during heat sterilization; others have low melting points to penetrate further into the suture under heat exposure. The biological

1 2 3

FIG. 1. No. 3-0 non-capillary silk (through knot) three weeks after being placed in intercostal muscles of dog.

FIG. 2. No. 5-0 non-capillary silk six months after being placed through pleura and costal periosteum of dog.

FIG. 3. No. 3-0 non-capillary silk processed to remove non-capillary coating six months after being placed in lumbar muscle of rat.

reaction to the suture is dependent on the coating and not on the suture material. (Figs 1 to 3.) This is particularly significant in the surgery of trauma, in which critical sutures are used in the anastomosis of blood vessels, tendons and nerves. Often we see the patient with a good, silk, tendon repair obtain good function by the third month after the repair, only to begin to lose that motion and have difficulties toward six months. This is not due to overactivity of the patient or to the technic of the repair. It is probably due to the wax granuloma which forms at a slow, progressive rate about that non-absorbable suture material. It is well known in vascular surgery that a graft or an anastomosis in the venous system may be patent for a few months but clots off around the sixth month. It is during the three- to six-month period that the wax granuloma reaches its maximum dimensions. Sometimes this clotting happens on the arterial side but this is less frequent because the head of pressure and rate of flow are sufficiently great. Some surgeons do the manufacturers one better by oiling or greasing the non-capillary suture before inserting it in the tissues. This is done to facilitate the pull of the suture through the tissues and to decrease the "tissue drag." The ultimate tissue reaction from this type of "do it yourself" procedure is like adding fat to the fire, giving an earlier granulomatous reaction and an ultimately larger one than would be expected from only the non-capillary coating.

One of the problems that is currently being investigated in our department is the true significance of capillarity and non-capillarity in sutures. Many of the suture manufacturers believe that the capillarity is of secondary importance and that the non-capillary coating improves the salability of the item by affecting the quality of the suture known as the "hand." There is no prescribed measurement for the hand of the suture. To approximate this property, I grasp the suture in a soft rubber clamp 3 inches from one cut end, hold the suture so that the clamped portion is horizontal with the floor and measure the angle of deflection of the 3 inch segment of the suture. The smaller the angle, the more easily is the suture handled in surgery. In all the non-capillary sutures examined, this angle of the dangle

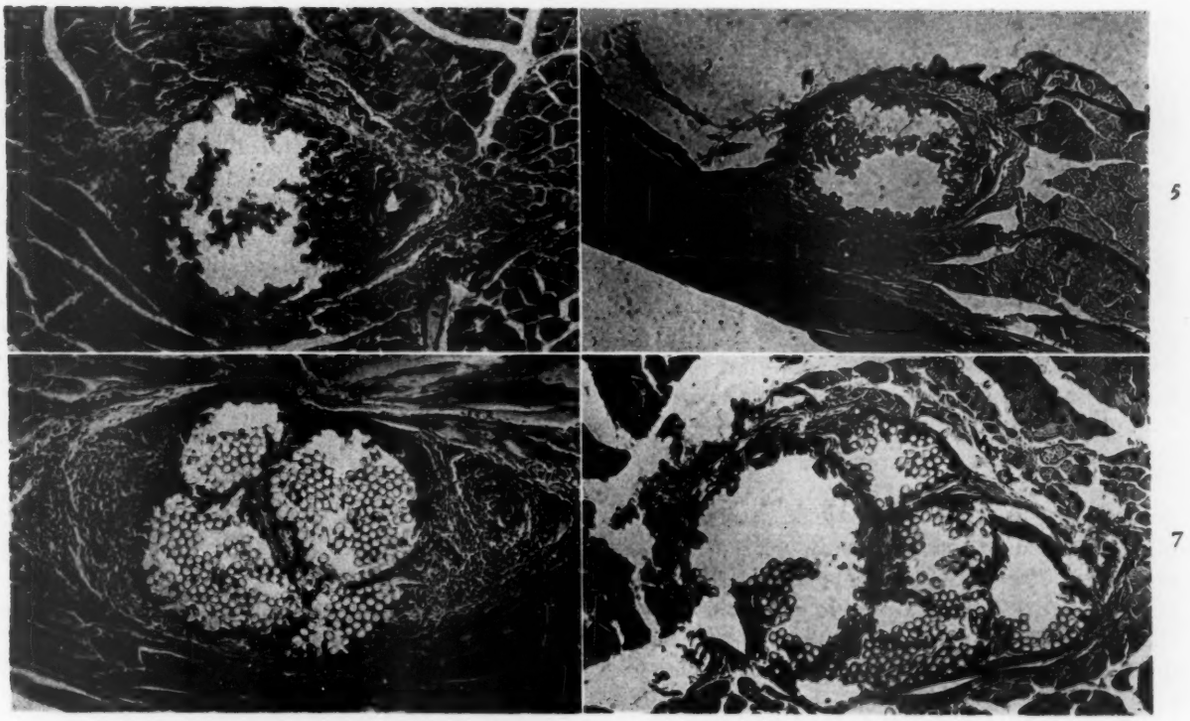


FIG. 4. No. 2-0 surgical cotton three weeks after insertion in lumbar muscle of rat.

FIG. 5. No. 2-0 surgical cotton six months after insertion in lumbar muscle of rat.

FIG. 6. No. 2-0 surgical nylon (through knot) three weeks after insertion in lumbar muscle of rat.

FIG. 7. No. 2-0 surgical nylon (through knot) six months after insertion in lumbar muscle of rat.

was inversely proportional to the amount of coating on the non-capillary suture. We are currently investigating the possibilities of improving the hand of the sutures by altering the tightness of the braid and by applying other coating materials which do not give rise to the wax or foreign body granulomas. To check this property of granuloma reaction some of the sutures were subjected to a decoating process; the difference can be seen by comparing Figures 2 and 3.

DRESSINGS

Dressings are defined in the textile trade as "compounds which, when applied to yarn, form a more or less continuous solid film around the yarn and the individual fibers. They are applied to sewing thread, to bind the strands together and leave a pliable yarn" [5]. These astatic dressings are necessary in the processing of the yarns, particularly when they are twisted or braided; if they are not applied, the fibers have enough static charge to foul the spinning or braiding machines. To remove this material from the yarn, we modified a procedure that was given to me by Dr. J. S. Tapp of the Chemstrand Corporation (this formula is also successful in removing the coating from the non-capillary suture materials): 3 twenty-minute boilings in a mixture of 1:1 benzene and methanol, using 100 cc. of the mixture per gm. of suture (working under a chemical hood or with condenser system, as the benzene-methanol fumes are very irritating); boiled for half an hour in distilled water, then half an hour in a 1 per cent solution of mild laundry detergent in distilled water, followed by 2 fifteen-minute boilings in distilled water. The suture material is then dried in a conduction oven before packaging for autoclave sterilization. If the suture has swedged needles, it is necessary to coat the needles with a silicone preparation following the three methanol-benzene boilings, to prevent the needles from rusting during the water boil-off; silicone stopcock grease is a satisfactory preparation. It is wiped off following the drying procedure. It is difficult to state of what clinical significance this dressing would be to the success or failure of the surgical

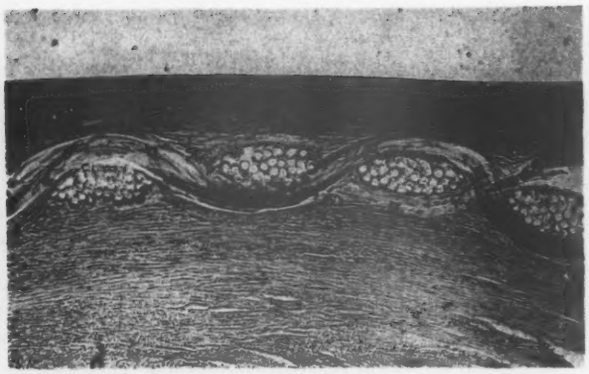


FIG. 8. PETP blood vessel replacement, processed to remove dressing, one year after aortic replacement in dog.

procedure. However, at three weeks those materials which had been processed showed none of the reaction which is seen in Figures 4 and 6. Figure 8 is the one-year specimen of a PETP aortic prosthesis which had been processed in the laboratory to remove the dressing. Figures 5 and 7 demonstrate that at six months any granuloma reaction which arose from the dressing material has disappeared, leaving a thin margin of scar tissue surrounding the suture foreign body. It is conceivable that the biological response about the nylon, as in Figure 4, might be sufficient to start a thrombus in a vascular anastomosis. The U.S.P. makes no mention of the dressings on the sutures and there is no limitation on the material used to compound the non-capillary coating. Again I wish to emphasize that the reactions to these coatings and dressings are most significant in surgery of tendons, vessels and nerves in which the suture material and the reaction about it are critical.

CONCLUSIONS

Surgeons are prone to blame the instrument nurse when sutures do not live up to their expectations. It is not the nurse's fault or the manufacturer's fault. The surgeon himself is responsible. The sutures that are sold today are standardized according to specifications in the U.S.P. If we, as surgeons, want surgical sutures, we must establish surgical standards to replace the present U.S.P. manufacturer's standards. The next revision of the United States Pharmacopeia is scheduled for 1960 [6]. It is urgent that if you want surgical standards to be incorporated into that revision, you must start action.

As the field of legal action narrows on the surgeon, and the surgeon specializing in trauma moves into the scope of that field, it is important that you protect yourself with standards for the materials that you use. The manufacturer's standards are protected, but these are not surgical standards. If something goes wrong and a complication develops due to suture failure, you are responsible, not the manufacturer. If you establish the standards, the manufacturer has to abide by them and you will both be protected from legal involvement.

SUMMARY

1. The physical properties of the non-absorbable surgical sutures are critical in the surgery of trauma.

2. The existing standards that protect these properties are manufacturer's tests that do not reflect surgical requirements.

3. The following changes in the U.S.P. tests and standards for non-absorbable surgical sutures are suggested:

(A) *Diameter.* (a) Present measurement with deadweight gauge be abandoned, and surgical standards be established by microscopic measurement. (b) Present requirement of one-quarter tensile strength tension for diameter determination be abandoned. Surgical requirement be substituted, of tension equal to force of "tissue drag."

(B) *Strength.* (a) Present standard of tensile strength be abandoned and the surgical standard of breaking strength be established. (b) Present requirement of testing immediately after removal from package be replaced by surgical requirement to condition sutures in animal fluid at body temperature before testing. (c) Surgical standards for knot breaking strength of conditioned sutures be established and included in the U.S.P.

(C) *Coatings and Dressings.* (a) Biological test standards that reflect surgical requirements be established and incorporated into the U.S.P. surgical suture standards. (b) The ingredients of non-capillary coatings be included on the label. (c) Dressings be removed from sutures prior to packaging.

4. A method for removing coatings and dressings is given.

5. A test for "hand" of suture is proposed.

6. The urgency of action to incorporate

surgical standards into the 1960 revision of the United States Pharmacopeia is expressed.

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Deficiencies of Stainless Steel Internal Fixation Units

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FAILURE of an internal fixation is always inconvenient and sometimes disastrous. The selection of metals suitable for use in the body has plagued the surgeon since the first use of metal implants, to which the body's reaction was so inevitable that the ends were left protruding through the skin to facilitate removal. When the austenitic stainless steels became available, they were widely adopted and are now the most commonly used material for the internal fixation of fractures. With increasing experience, three deficiencies have been observed that detract from its usefulness. Its strength is inadequate for many applications; it is far more susceptible to corrosion than anticipated, and if corroded it loses most of its resistance to stress.

In industrial applications the stainless steels have been extensively used where chemical attack is a major problem, but it has surprisingly failed in a number of relatively innocuous circumstances. Paper makers have noted the breakage of lightly loaded stainless steel parts of machinery exposed to sodium bisulfite; the Air Force has found stainless steel aircraft engine exhausts completely disintegrating on long-range flights and watch manufacturers have reported the cracking of watch cases through the action of perspiration. Because of rapid corrosion in sea water, some metallurgists now advise against the use of stainless steel in weak chloride solutions, which would include tissue fluids.

In the light of these experiences in other applications, we are presenting a résumé of our clinical experience with stainless steel implants in conjunction with experimental observations suggesting that compound stainless steel devices possess an irreducible potential for eventual corrosion.

CORROSION

Type 316 and 317 stainless steel, commonly designated SMo, contain chromium and molybdenum for their capacity to inhibit corrosion while nickel stabilizes the crystal structure as austenite, which is the most resistant form of this alloy. Perfectly prepared stainless steel implants are protected from the action of body fluids by a microscopic surface coating, produced by electropolishing and immersion in nitric acid which oxidizes the surface chromium to a corrosion-resisting chrome oxide layer 10^{-5} mm. thick. While this film adequately protects the device if unblemished, it is easily disrupted at points of contact and by rough handling.

Corrosion is the dissolution of metal. Consequently its activity can be measured by the loss of weight occurring with the metal immersed in plasma over a prolonged period of time. This is the method adopted by the Armed Forces for testing stainless steel implants. Under these conditions single components show insignificant loss of metal.

Unfortunately this type of measurement does not take into consideration the disruption of the surface that occurs at metal junctions, such as the screw with the plate or the abrasion of the surface of the plate during its application. These defects become the site of origin for highly destructive pit corrosion which may progress through the cross section of the piece while the remaining surface continues to appear bright and shiny.

EFFECT OF CORROSION ON TISSUES

With corrosion of appreciable degree, metal particles of the disintegration may stain the surrounding tissues. (Table 1.) The body

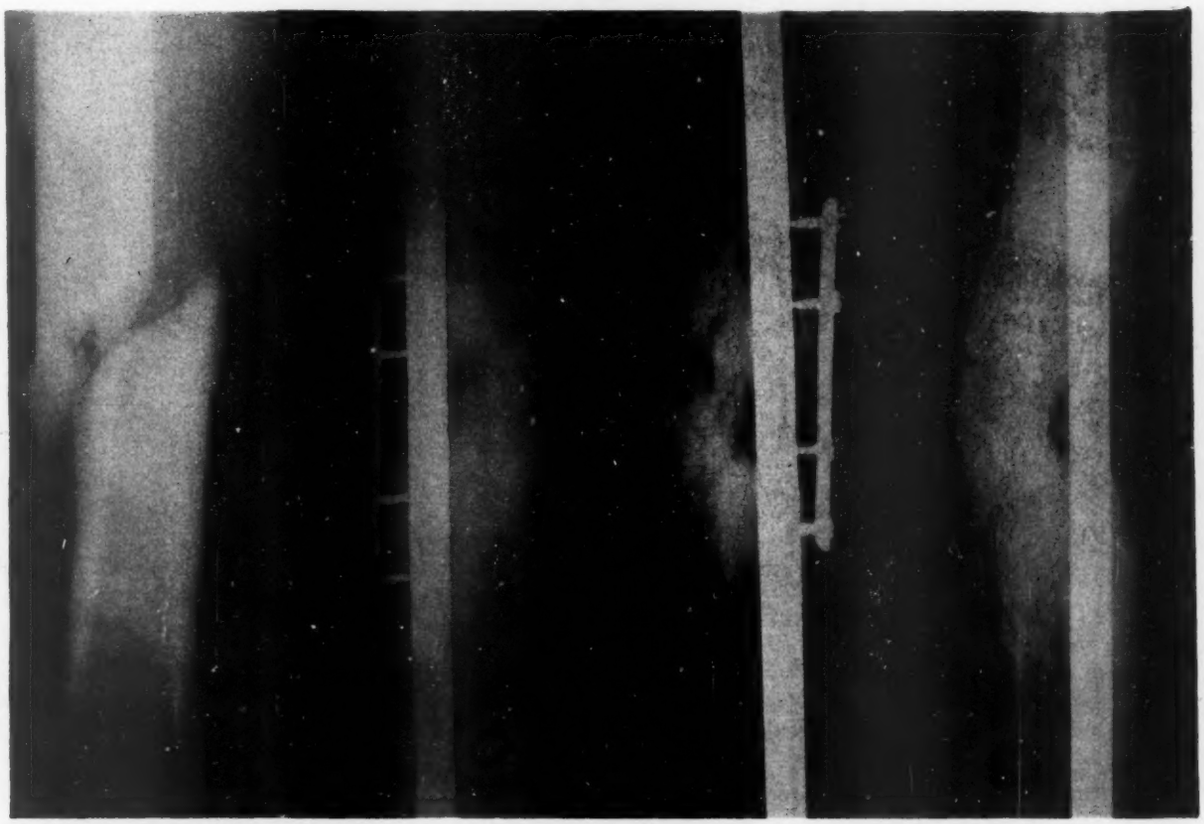

FIG. 1. Electrolysis between the Küntscher nail and coaptation plate has resulted in massive resorption of bone. Battery action was halted by removal of the plate and screws.

responds with fibrous tissue in an attempt to wall off the irritant. If successful the process remains confined, but with superficially placed metal there may be disruption of the overlying skin with subsequent secondary infection. The bone about corroding metal is decalcified by electrolysis. (Fig. 1.) It is partially replaced by fibrous tissue, decreasing the purchase of the metal on the bone with hazard to the stability of the immobilization. This activity is apparent when removing stainless steel screws which are frequently loose, as contrasted with Vitallium screws which usually take the same amount of effort to withdraw as to insert.

EFFECT OF CORROSION ON METAL

Uncorroded SMo steel has a capacity to support strains only a fraction of the magnitude sustained by normal bone. Martz [1] has compared the breaking point of bone with metal and the forces developed in certain body actions. In turning a doorknob a torsional force of 60 pounds may be developed in the forearm, while a 3 inch Sherman plate will withstand only 15 pounds of torsion. The tibia will support 800 pounds of transverse force, while a 6 inch Lane plate will break at 165 pounds. At the hip, the patient weighing 150 pounds exerts a force of 2.5 times the body weight or nearly 400 pounds with each step. The intact femoral neck will support 1,930 pounds, a Vitallium Eicher prosthesis 1,870 pounds while the same device in stainless steel will break at 360 pounds. There is a vast area for improvement in material and design to yield appliances which would approach the strength of normal bone—an

TABLE 1
CORROSION EFFECTS

Tissue:
Foreign body reaction
Sinus formation and infection
Bone decalcification
Metal:
Dissolution of metal
Stress failure
Fatigue failure

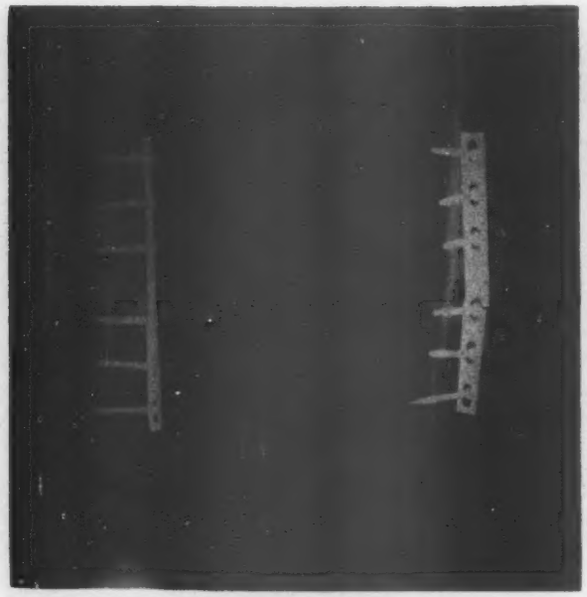

FIG. 2. The six-hole slotted plate broke at the screw hole adjacent to the fracture site. Since strains are highest in this area, it is the usual point for failure.

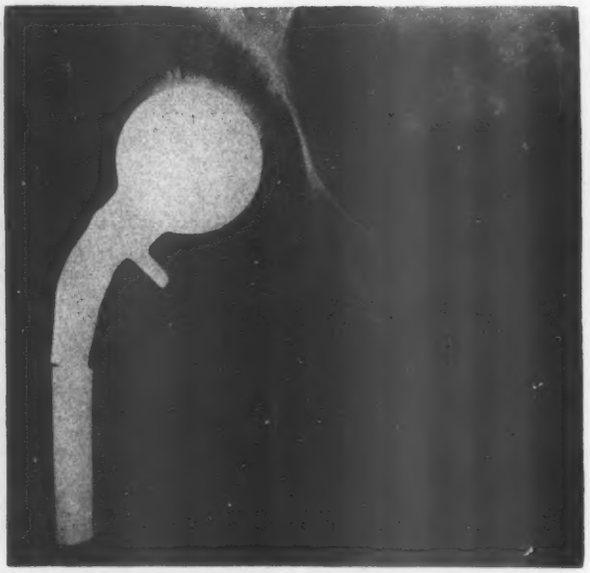

FIG. 3. An Eicher prosthesis was inserted in 1953 because of aseptic necrosis of the femoral head following subcapital fracture of the femoral neck. The patient walked satisfactorily until 1956 when pain developed in the hip. The broken stem of the prosthesis is an example of fatigue failure.

optimum essential for prostheses and desirable for fracture fixation.

The junction of plate and screw is the usual site for the origin of corrosion since the protective film is disrupted by abrasion at the contact point; this is also the site of action for any strain placed on the device. (Fig. 2.) Stress accelerates corrosion; their interaction, termed stress corrosion, markedly weakens the metal.

Fatigue of metal occurs when it is subjected to altering strains. Minute cracks are propagated through the metal which expose additional areas to electrochemical attack. Through the potentiating effect of corrosion and fatigue, the metal may lose as much as 80 per cent of its strength. Thus appliances may fracture long after insertion without any increase in the load placed on them. (Fig. 3.)

Even under the best circumstances, the stainless steel devices possess insufficient strength for many of the applications in which they are used. With the additional weakening produced by stress corrosion and corrosion fatigue they are entirely inadequate.

CLINICAL EXPERIENCE

To assess the magnitude of complications due to metals, we have reviewed all open reductions with internal fixation by metal, except wire, for the five-year period between 1950 and 1955. From a total of 636 patients, 384 were available with follow-up films of two months and longer at Hurley Hospital. It is anticipated that with the passage of time additional instances will develop since corrosion is a progressive process. We recently removed a Parham band from the thigh of a patient operated upon twenty-two years previously. She had been symptom-free until a sinus had developed. On removal the metal was grossly corroded and the surrounding granulations were stained with the brown products of metal disintegration.

TABLE II
CLINICAL EXPERIENCE

	Patients	Percentage
Internal fixation with metal.....	636	..
Followed up two months or longer	384	..
Complications due to metal.....	39	10
Associated with non-union.....	23	6
Associated with delayed union..	11	3

Thirty-nine of the group of 384 had x-ray evidence of fracture of the fixation metal or bone absorption about it. (Table II.) In many instances both processes were evident, which is consistent with the concept that corrosion

and strain potentiate each other. In this group of thirty-nine patients there were twenty-three non-unions.

All fifteen patients with broken devices had poor results, manifested in eleven by non-union, in one by a broken Eicher prosthesis after three years, and in three by delayed union. (Table III.)

TABLE III

Broken Devices

Device	Non-union	Delayed Union
Eicher prosthesis	1	..
Plate	5	...
Küntscher nail	2	..
Screws	4	2
Web bolt	..	1

Electrolytic Osteitis

Device	No Effect	Non-union	Delayed Union
Plates and screws	4	7	6
Smith-Petersen nails	2	1	..
Rush pins	..	2	2

Bone resorption, variously termed electrolytic osteitis or rarefying osteitis, was noted in twenty-four patients. In ten instances there was associated non-union, and in eight healing was definitely prolonged. Six patients had minimal reactions and no appreciable interference with healing. In four of these the process was confined to a single screw and the other two occurred about Smith-Petersen nails.

A number of patients in whom sinuses developed were excluded since it was not possible to differentiate between corrosion reactions and infection without chemical analysis of the surrounding tissue for metal corrosion products.

THE PROBLEM OF ELECTROLYSIS

Electrolysis is the most important factor in the development of corrosion. This is the formation of a battery between two points of different potential in an electrolyte solution. Metal is removed in the form of ions from the anode. There are two mechanisms for the formation of a battery with stainless steel implants.

Venable and Stuck [2], in classic studies conducted twenty years ago, proved that corrosion between different metals in the body could be predicted from their potential difference as determined by their position in the electromotive series of metals. This cannot be estimated for alloys; however, any two metals of different composition when placed in an electrolyte solution will develop a current if both are soluble. This variation in potential between metals of different composition is the reason for selecting devices of exactly the same constituents.

Another source for the development of electrolysis resides in the formation of anodes at any site where metal is deformed by pressure, bending or abrasion. A familiar example is the bent nail, which rusts first at the bend since this area is anodal to the undeformed portion. Because areas of stress are present in compound implants (i.e., those consisting of more than one component), they possess a distinct potential for corrosion.

In an attempt to develop a simple non-destructive test to supplement inspection in the differentiation of screws and plates of varying composition, a vacuum tube voltmeter was employed to measure potential differences. Any components varying more than 100 millivolts from the currently available materials were discarded since currents in excess of 6 microamperes were generated in saline with this voltage—an intensity adequate to decalcify bone.

The most important finding, however, was the presence of small variations, that is within a range of 20 millivolts, between screws of the same composition. This difference is due to the deformation of the screw in the machining necessary to form it. Screws are made on cutting machines which tear the grooves into metal blanks. This electrical variation represents an irreducible potential for corrosion that all machined SMo implants manifest.

SUMMARY

Among 384 patients with stainless steel implants there was a 10 per cent incidence of broken metal and rarefying osteitis as manifestations of inadequate strength and corrosion. Eighty per cent of these were associated with non-union and delayed healing. Compound implants of SMo are inherently susceptible to corrosion in body fluids. The rate of the reac-

tion depends on the electrolytic currents generated between components, the intactness of the passivating film and the action of stress and fatigue forces. The incidence of the sequelae of corrosion can be reduced by the careful selection of materials of the same composition, gentle handling and early removal.

Experimentally we have determined the presence of small variations in potential between screws of the same composition which is apparently a function of the manufacturing process in which there is deformation of the metal during the cutting of screws. Although the currents generated at these low voltages are of small magnitude, they possess the potential for corrosion that is present in even the most carefully applied internal fixation.

These findings suggest the use of more inert metallic units and that research should be directed to this end, whatever the name of the alloy or metal turns out to be.

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DISCUSSION OF PAPERS BY DRS. BLUNT; AND CURRY AND PINE

Donald M. Glover (Cleveland, Ohio): Dr. Blunt asked me to say a word in opening the discussion of his paper.

Some twenty years ago when the responsibility of the surgical service fell on my shoulders, I was impressed with the confusion that existed among the various surgeons and in the equipment of our armamentarium of suture materials. This is something which has impressed all of us.

In attempting to develop some rational procedure, we attempted to evaluate sutures as they existed then, with an effort toward making more uniform the practices of the various surgeons. It is important for surgeons to know what sutures they are using, and particularly, how they react in tissues.

One point that I want to comment on a little more emphatically is the fact that, as Dr. Blunt has mentioned, there is actually no true biological standard in suture manufacture. To me, that feature of the proposed standards is the most important of all. We, it seems, should insist upon having some type of biological standard which can be at least roughly described to give us a yardstick for judging tissue reaction about a suture.

Again I want to emphasize what Dr. Blunt has said, that this really is our problem, and we should make our wants known to the suture manufacturers and the Food and Drug Administration.

Preston A. Wade (New York, N. Y.): I had the opportunity to read the paper by Drs. Curry and Pine at my leisure and I found it very informative. It has given me a little different attitude toward internal fixation devices.

I think we have all had, in a way, sort of a false sense of security in using SMo stainless steel or Vitallium, without much regard for their manufacture. I think this is one thing we should look into.

As you know, Dr. Barr, from the American Academy of Orthopedic Surgeons, and Dr. McLaughlin, from the college and this organization, are working on that very thing—the use of metals in the body. Perhaps this paper will help them.

We have been loath to throw away an $85.00 prothesis that we have removed from a patient, and I have saved them to give to the City Hospital where I used to work and had to pay for my own material. I used to save these things and use them over again. That is wrong, of course. We bent our material without any doubt that it would hurt the material. We know that it has some potential danger, but we bent plates and rods. As you know now, Vitallium, in order to catch up with SMo stainless steel, advertises that Vitallium will bend. I am sure you have seen the bender for their new Rush nails. It bends the nails into position.

We will have to remember, eventually, all these things, and use more care in the selection of our material. But it is up to us to initiate the standard for the manufacturers.

Now I understand that the manufacturers of stainless steel vary their material a great deal, and we cannot, by looking at the metal, tell the composition, the Rockwell hardness or anything else. I think perhaps the Austenal people have something when they say all their material is made in one place under definite standards. I do not want to get into the stainless steel vs. Austenal discussion. That caused such an upheaval in this group a long time ago. Perhaps Dr. Pine will want to say something about the difference between Austenal's Vitallium and SMo's stainless steel. We can have it off the record, if you like. But certainly those of us buying it want to know.

There is one other thing I would like to say. Compression of bones causes resorption, and because one puts the plates in the tibia at the junction of the lower and middle third and it does not heal or is slow, that is not the fault of the material. I think we often ask too much of the material. If we use it there is some compression of the bone, and it should be used only long enough for the bone to heal. Then it should be removed. There are exceptions, of course, where the prothesis is supposed to last forever. I do want to say that we cannot ask

too much of the material and put it in a place where we know the stress and strain is going to be too much for it.

LESTER BREIDENBACH (New York, N. Y.): About twelve years ago, on the Fourth Division at Bellevue, we went through all these tests on various suture materials and finally came to the conclusion experimentally, in a research way, that cotton was the best suture material we had at the time. We all started using cotton over a period of twelve years.

There is one index that never comes out in our experimental and research work. Dr. Blunt did not mention it, maybe, because he did not have time. That is the index of the sinus formation in the use of non-absorbable suture material. This is a very important test. We went along for a good period of time with an occasional cotton sinus which, of course, is very embarrassing to the surgeon and the patient; it is sometimes necessary to take the patient back to the hospital and clean out all the foreign bodies before complete healing is obtained.

Then we had the so-called increase of hospital room infections on the basis of a staphylococcus organism about which everyone has been talking and probably on a letdown of technic in the operating room. Then the sinuses occurred by the score, so most of us quit using cotton and went back to catgut. Up to the present time most of the men have stayed away from cotton because of this particular complication, which ought to be mentioned in the use of any type of suture material—non-absorbable suture material—as an index of its good quality.

J. W. BLUNT (closing): Dr. Glover mentioned that if you want something, you should make it known to the suture companies. Do not waste your time. If you want something, let the Food and Drug Administration know. They are the policemen. If you ever receive a bad lot of anything, do not deliver it back to the salesman. He will replace it and say he is terribly sorry that this happened. Send it to the Food and Drug Administration and it will be straightened out immediately. They will send an inspector around and will find out what the trouble is, and stop it right quick.

I have one other comment on the sutures. One of the problems and difference between cotton twelve years ago and the cotton today is a change in the dressing material. In the old days, say twenty years ago, cotton was dressed with starch. You have to put something on the cotton or it cannot be handled on the weaving machines. A few years ago plastic dressings came into use, and that does not wash off. The reactions and sinuses arising today are probably a result of these dressings.

DONALD K. PINE (closing): In regard to Dr. Wade's discussion, I think he is familiar with the fact that the manufacturers are aware of these problems with stainless steel. Some of them now package with these devices a report of the analysis of the metal content of the appliance. In surveying our supply of internal fixation units we found some devices that were dangerous. Infrequently used items, such as short Smith-Petersen nails, which had been in our surgical supplies for many years, were unpolished and definitely of different composition. It is quite often worthwhile in your own hospital to check the materials, especially those lying in the back of cabinets.

As far as other metal work is concerned, some is going on. We have been evaluating other more inert metals, but we certainly have not had enough experience to comment on it.

Injury to the Axillary Artery Following Anterior Dislocation of the Shoulder

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REPORTS of injury to the axillary artery following dislocation of the shoulder have been few in number. A review of the Surgeon General's Index Catalogue from 1918 to 1936 and the Quarterly Cumulative Index Medicus from 1936 to 1956 revealed six papers reporting a total of eight instances of thrombosis or rupture of this artery complicating injury to the shoulder [*1,4,5,9,10,12*]. De Palma [*3*] mentions that he saw one case of severance of the axillary artery following dislocation of the shoulder. The possibility that these injuries may occur more frequently than commonly supposed and the need to propagandize one of the newer concepts of vascular surgery prompted us to record the following two cases that were encountered within a period of six weeks.

CASE REPORTS

CASE I. A. L. (C. G. H., No. 340-6-85), a seventy-three year old white man, tripped on linoleum at home shortly after midnight on February 2, 1957, injuring his right shoulder. After the immediate severe pain had subsided, he noticed that his right hand was becoming cold and numb. He was admitted to the Cincinnati General Hospital at 4:00 A.M., where a diagnosis of anterior dislocation of the right shoulder was made. In addition, it was noted that he had no pulse at the wrist or in the arm, even though all pulses were present in the left upper and both lower extremities. The shoulder was reduced immediately by the Hippocratic maneuver but the pulse did not return. A stellate block was done at 5:05 A.M. and Horner's syndrome obtained. The hand seemed to be improved a little in that it became warmer, but the pulse remained absent. The stellate block was repeated at 6:45 A.M. and again Horner's syndrome obtained. Again, however, the pulse remained absent. The patient was seen in consultation at 8:45 A.M. and immediate exploration of the axillary artery was recommended. The operation was performed* at approximately 10:00 A.M. The distal portion of the axillary artery and the proximal portion of the brachial artery were exposed through a longitudinal incision parallel to the course of the brachial artery. The point of occlusion was just distal to the posterior circumflex artery and consisted of a firm segment approximately 1.5 cm. in length. The segment contained a fresh thrombus lying proximal to a portion of torn intima which had become undermined and had flapped distally. The vessel wall in this area was markedly arteriosclerotic, presenting a very small lumen. It is believed that the trauma of the dislocation had fractured the intima, causing complete occlusion of an already stenotic arteriosclerotic vessel. A thromboendarterectomy was carried out but the flow of blood was not satisfactory. Accordingly, the proximal brachial and distal axillary arteries were freed up, a 3 cm. segment of the most involved portion was resected and an end-to-end anastomosis was carried out using two continuous sutures of No. 5-0 arterial silk. After the clamps were removed, the radial pulse returned but disappeared a few minutes later. Therefore a small incision was made distal to the anastomosis, and a new, fresh clot was removed by suction. Ten cubic centimeters of saline solution containing 10 mg. of heparin were injected distally and the arteriotomy incision was closed. The pulsation at the operative site was now much improved and the radial pulse was strong.

The patient's postoperative course was uneventful. He was examined several times in the follow-up clinic, and on each occasion the radial and ulnar pulses were easily palpable.

CASE II. L. F. (G. S. H., No. 80326), a fifty-four year old white woman, fell on her left shoulder, sustaining a subcoracoid dislocation of the left humeral head, on March 11, 1957. At first the arm and hand were cyanotic but the color improved

* Surgeon, James Giacobine, M.D.

immediately following reduction by the Hippocratic maneuver. However, no pulse was palpable in the radial, ulnar or brachial arteries. Oscillometric examination confirmed the absence of pulsation. Since the collateral circulation appeared to be adequate for survival of the limb, the patient was started on heparin therapy in the hope of preventing further thrombosis. However, twenty-four hours later some numbness of the arm began to develop and so it was decided to explore the artery. Under general anesthesia, an incision was made along the course of the brachial and axillary arteries. The brachial artery was identified and found to be pulseless. It was traced up to the mid-axilla where the vessel was found to be severed completely. The proximal portion of the artery was mobilized and about 1 cm. resected. The ends were then sutured together with No. 5-0 arterial silk. Immediately postoperatively all the pulses returned and the arterial circulation has remained excellent.

COMMENTS

The collateral arterial pathways about the shoulder joint are so extensive that gangrene of the upper extremity does not occur following occlusion of the axillary artery unless the collateral arteries are also injured or secondary thrombosis occurs. If gangrene be the only criterion of arterial injury, most injuries to the axillary artery would not be detected. Functional impairment of the viable limb may, however, be of major consequence. One can only speculate on how many extremities with muscular weakness following dislocation of the shoulder have vascular impairment rather than injury to a nerve as the prime etiologic factor.

In the absence of obliterative arterial disease (which rarely causes occlusion of the major arteries of the upper extremity) absence of the pulse at the wrist following injury to the shoulder or arm indicates proximal occlusion of the major artery. The artery may be compressed, contused, lacerated or severed, but in any case, direct exploration is indicated if one aims to restore normal circulation. Granted patency of the major artery is not always necessary for survival of the limb; nevertheless, it is of major importance to many patients and desirable for all.

Repeated blocking of the stellate ganglion in an attempt to prevent gangrene of the upper extremity is of highly questionable value. Certainly autonomic blockade will not influence a compressed, lacerated or severed artery and, contrary to popular opinion, will not release localized or "segmental" arterial spasm [7,8]. Furthermore, the concept of reflex spasm of the arterial tree distal to the site of injury to account for the diminished caliber of the artery is rejected for lack of positive evidence of the existence of such a reflex and because this phenomena can be satisfactorily explained on a physiologic basis by a fall in intraluminal pressure [2,8]. Finally, if the viability of the limb is threatened by progressive arterial thrombosis and surgical exploration cannot be performed, the use of heparin would be of greater value than vasomotor paralysis; and since stellate blocks cannot be performed safely in a heparinized patient, it would seem that their use has little if any place in the treatment of arterial injuries of the upper extremity. Instead, primary emphasis should be placed on restoration of continuity of the major arterial pathway, and for this, surgical exploration of the injured site is indicated.

SUMMARY

Two instances of injury to the axillary artery secondary to anterior dislocation of the shoulder are reported. In each case it was possible to restore arterial continuity. The possibility that this type of injury is more common than indicated by the paucity of case reports is suggested.

Anesthetization of the stellate ganglion has little place in the treatment of acute arterial injuries of the upper extremity. Absence of a palpable pulse at the wrist following injury to the shoulder or arm indicates occlusion of the major artery and is a prime indication for immediate exploration of the artery at the site of injury.

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Methods and Results in the Treatment of 2,580 Painful Shoulders

WITH SPECIAL REFERENCE TO CALCIFIC TENDINITIS AND THE FROZEN SHOULDER

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THE basis of all studies upon the shoulder is the book of Codman [*10*], the material of which could be read and reread by everyone with profit. Codman's recommendations and conclusions are valid today, being amplified only by the present day accumulation of experience with a greater number of cases, clarification of detail and a few new methods. Codman's autopsy data, fixing the incidence of severe degenerative changes in the tendon structures about the shoulder as 32 per cent, is confirmed by more recent and detailed investigations (Wilson [*50*], De Palma [*13*], Neviaser [*38*], Neviaser and Eisenberg [*39*], and others). At various points in this paper quotations will be made from Codman's pioneer study to demonstrate the validity of his ideas.

I have been interested in the disorders of the human shoulder for many years, and my observations upon the results of treatment of two groups of cases will be presented herein: calcified tendinitis of the rotator cuff, and the so-called "frozen" shoulder. This presentation is based upon a personal experience with 609 and 803 cases, respectively, of these disorders from a total of 2,580 painful shoulders seen during the past seventeen years and upon which adequate records are available.* This has been a continuing study during this time, the data of the aforementioned number of cases being summarized now. In addition to the cases personally conducted, clinical records and/or roentgenograms have been available on approximately the same number of additional cases. The observations and conclusions drawn here are therefore based upon well over 5,000 painful shoulders.

It is my opinion and conclusion that (1) the natural course of the two conditions under consideration can be favorably influenced by treatment properly applied as to time in the cycle of these disorders; (2) many of the variable treatments now in general use, especially various types of radiant energy and "shots," are non-effective except for their psychotherapeutic value; (3) large- and medium-sized troublesome calcium deposits can be promptly cleared from the shoulder tendons by minor procedures, but the patients must be carefully supervised to prevent complications; (4) pessimism about the outcome of the frozen shoulder, particularly in regard to (a) setting up rigid time-limited minimum recovery schedules, and (b) the benefits of closed manipulative treatment, is not justified; (5) these and other conditions of the shoulder joint deserve continuing study to improve both prevention and treatment.

No attempt will be made to review the voluminous literature except to cite contributions that are considered as milestones in progress. Codman pointed out fifty years ago that calcium deposits encountered about the shoulder were found most frequently in the distal portion of the supraspinatus tendon, and that foci of tendon degeneration preceded or coincided with the deposit. He pointed out that the deposit was not within the bursa but neither was the subdeltoid bursa calcified. In spite of this, and repetition by many more modern observers from time to time, uncritical physicians and lay persons continue to desig-

* The majority of the records and cases utilized in this report are from the Kaiser Foundation Hospitals in Oakland, Vallejo and San Francisco, California.

nate all the painful conditions of the shoulder "bursitis," a term that serves only to confuse.

Availability of roentgen ray diagnosis leads the unwary physician into the trap of treating the roentgen film rather than the patient. Much anxiety and treatment is wasted on the asymptomatic or little significant calcium deposit, and the patient with a painful frozen shoulder has often been informed that "there is nothing wrong," simply because the roentgen film shows no spectacular changes. The patient may be treated for "osteoporosis," the effect of disuse, or for some imaginary neuralgic disorder because the pain may radiate into the arm, forearm or hand, or into the neck or head. Poor understanding plus the present popularity of various "shots" of hormones, vitamins and "antirheumatic drugs" and the widespread use of impressive-looking machines delivering variable outputs of diverse forms of physical energy in a largely self-limiting, non-fatal disease, further confuses both physician and patient. To add to this dilemma, certain cases of calcified tendinitis of the rotator cuff tendons, as well as the insidiously progressive frozen shoulder of middle age, remain troublesome for long periods because active resumption of motion, the single most important factor, is neglected. Ineffective and illogical treatment destines the patient for much pain, suffering, "change of doctors," neurosis and other undesirable phenomena. Not the least confused are physicians who argue that the frozen shoulder cannot result from degenerative causes because normal motion is so frequently obtained after treatment.

PERTINENT LITERATURE

Bosworth [7] reported a survey of roentgenograms of 6,061 office workers covering many years of their lives. He presented the calcified deposit in the cuff tendons of the shoulder in its proper perspective in this group. Deposits, chiefly asymptomatic, were found in 2.7 per cent. In this group female office workers comprised 76.7 per cent of the number; 94.1 per cent either did clerical work or used typewriters or other manually operated office machines. Sooner or later, calcified deposits larger than 1.5 cm. gave rise to symptoms. Trauma had little to do with onset of acute symptoms (seven of forty-one cases, 17.1 per cent). The calcific deposit disappeared spontaneously in only thirteen of 138 shoulders (9.3 per cent) within the three-year observation period. He also found that 34.6 per cent of deposits of all sizes caused symptoms at some time. It was his opinion, supported by everyone who has had experience with these calcific deposits, that the quickest and most dependable method of ridding the patient of the larger and most troublesome deposits is by open operation through a small transdeltoid incision. This opinion is affirmed by Bosworth [8], Howorth [21], McLaughlin [30], Wilson [50], Abbott et al. [2], Moseley [34], Mead [33], De Palma [13], Friedman [16], and myself. McLaughlin contributed a description of the pathology, life cycle and treatment of calcific deposits.

On the other hand, Patterson and Darrach [42], Lapidus [26], McLaughlin, Friedman and many others have indicated that needling to effect local release of tendon tension and the injection of local anesthetics permitted motion, suppressed pain and led to recovery including absorption of the deposit in many cases, making open surgery unnecessary.

For years the roentgen ray treatment of the painful shoulder, including disorders due to calcific tendon deposits and poorly classified conditions labelled "bursitis," has been extolled in numerous articles. The non-effectiveness* of x-ray treatments has recently been pointed out in a controlled study of thirty-eight patients by Plenk. A group of twenty-one patients exposed to x-ray were matched against a similar age and occupation group of seventeen persons who went through the same ritual of "treatment" but who were shielded by 5 mm. of lead. The incidence of relief of symptoms and restoration of complete motion was the same in both groups. The disappearance of calcium deposits was observed in a greater percentage (67 per cent) in the unexposed group than in those receiving roentgen radiation (44 per cent). A statistical analysis of the data confirmed the "no effect" hypothesis.

Considerable confusion exists regarding the advisability of manipulating the frozen shoulder under anesthesia in attempting to regain motion. Codman, Dickson and Crosby [14], Withers [52], Simmons [46], Quigley [44] and others recommended manipulation except

* Mead cites the similar previous work of Plenk and Crowder on 100 controlled cases with "results that did not favor the treated group."

during the acute or advancing stage. Key and Conwell recommend "full range manipulation" while Watson-Jones [49], Moseley and Quigley perform gentle manipulations during the quiescent and recovery phases. Some authors are definitely opposed to all manipulations under anesthesia (Lippman [27] Caldwell and Unkauf [5], De Palma, McLaughlin). Böhler [6] does not mention manipulations under anesthesia but recommends active and passive mobilization from the abducted position of an aeroplane splint. Key and Conwell recommend aeroplane splints following manipulation. Others are silent on this latter point or feel that exercises following manipulation are just as well begun from the side resting position. McLaughlin recommends open division of anterior contracted structures plus ablation of the intra-articular portion of the tendon of the long head of the biceps. De Palma and Lippman recommend a similar procedure with transference of the tendon of the long head of the biceps to the coracoid process. Critical analysis of the recovery time of near-full motion in the cases of the latter two authors shows prolongation of many months beyond that obtained by others by exercise and judicious manipulations (Dickson and Crosby [14], Quigley [44] and myself). Armstrong [4] recommends excision of the acromion process; Wagner [48] noted recovery of motion in the shoulder following partial outer claviculectomy. McLaughlin doubted the effect of acromiectomy and attributed the recovery of motion to manipulation of the joint while the patient is under anesthesia. Watson-Jones, who recommends acromial excision for the painful mobile shoulder, does not apply this operation to the frozen shoulder but emphasizes gentle exercises almost exclusively.

TABLE I
CLINICAL DIAGNOSTIC SUMMARY OF 2,580 PAINFUL SHOULDERS

Clinical Diagnosis	No. of Cases
Frozen shoulders	803
Calcification in cuff tendons	609
Supraspinatus tendinitis (abduction pain, tuberosity tenderness)	887
Biceps tendinitis (localized findings)	154
Ruptures of tendon of long head of biceps	76
Manifest ruptures of cuff tendons	44
Dislocations of biceps tendon	7

MATERIAL AND STATEMENT OF PROBLEMS

A summary of clinical diagnoses of the present group of 2,580 painful shoulders is given in Table I, and an itemized tabulation of the most common conditions that lead to the frozen shoulder in Table II. It should be pointed out that the diagnoses in Table II have been established upon the basis of the usually accepted physical and roentgen criteria. The shoulders were classified as to the predominating condition found on the first examination and were

TABLE II
ETIOLOGY OF FROZEN SHOULDER

I. Idiopathic (median age fifty-four years)
II. Secondary* (median age forty-nine years)
  A. Soft tissue disorders about shoulder
    1. Tendinitis with calcific deposits
    2. Tendinitis without calcific deposits
    3. Biceps tendinitis
    4. Trapezius and other "fibrositis"
    5. Muscular tension phenomena
    6. Shoulder dislocations, especially unrecognized posterior types
    7. Vasomotor phenomena (shoulder-hand syndrome)
    8. Failure to exercise after upper extremity fractures or trauma
    9. Infectious subdeltoid bursitis
  B. Osseous abnormalities
    1. Congenitally long acromion
    2. Exostoses and degenerative cysts in greater tuberosity
    3. Acromioclavicular degenerative arthritis
    4. Coracoclavicular degenerative arthritis
    5. Exostoses in bicipital groove
    6. Tuberosity and other fractures
  C. Neurologic
    1. Brachial root neuritis
      a. Osseous
      b. Disc
    2. Scalene and other thoracoclavicular syndromes
    3. Trauma to upper roots of plexus
    4. Tumors of soft tissues of neck
    5. Causalgias
    6. Parkinsonism

*List of some other conditions that have been observed by the author with secondarily frozen shoulders: chondrosarcoma of the upper humerus; tuberculosis of the glenohumeral joint; osteoblastic osteogenic sarcoma of the clavicle; aneurysm of the brachial artery in the axilla and under forearm flexors at the elbow; neglected pectoral and deltoid muscle ruptures; traumatic hemorrhages into the arm interfering with the biceps mechanism; prolonged subluxation of the humerus.

not later reclassified if another condition was observed as a complication. If two or even three conditions were found either simultaneously or consecutively in a single patient, the diagnosis assigned was that of the initial predominatingly disabling condition. This will

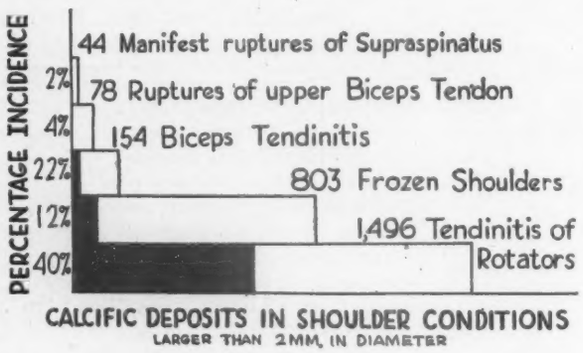


FIG. 1.

allow a later discussion of complications observed in treatment. For example, calcific tendinitis may be complicated by the frozen shoulder. If a significant degree (loss of more than half the abduction range) of freezing was present, the diagnosis assigned in this tabulation was frozen shoulder. If a calcific deposit was observed whose roentgen shadow was greater than 1.5 cm. (a large deposit according to the Bosworth classification, also utilized in this study), the diagnosis recorded was calcific tendinitis irrespective of the range of passive motion of the shoulder. A certain unknown number of the cases of "supraspinatus tendinitis," referring to abduction pain, localized tuberosity tenderness and normal passive motion, were mild and moderate tears of the rotator cuff fibers of insufficient size to produce significant lack of abduction power and range after local infiltration with procaine or other local anesthetic. Arthrography (Kernwein et al. [24] and others) was not employed as a routine diagnostic aid since the arthrographic findings have limited bearing on clinical treatment including selection of cases for surgical repair.

The questions which we were endeavoring to answer in this study were the following: (1) What are the reliably proved procedures for ridding the patient's shoulder tendons of calcific deposits and at the same time promoting full recovery of function? (2) What is the mechanism and significance of the deposition of calcium in the rotator tendons? (3) What is the time required for (a) deposition and (b) disappearance of calcific shadows in the roentgenogram? (4) What are the alterations of the frozen shoulder, anatomically and functionally, that have a bearing on treatment? (5) Does any type of treatment, especially forced manipulation under anesthesia, promote recovery of the frozen shoulder, and can the "life cycle" of the frozen shoulder be modified by treatment? (6) Are the injectable cortone suspensions (hydrocortone® and prednisolone) of any aid in the treatment of the painful shoulder? (7) What methods are available for the relief of pain in these conditions?

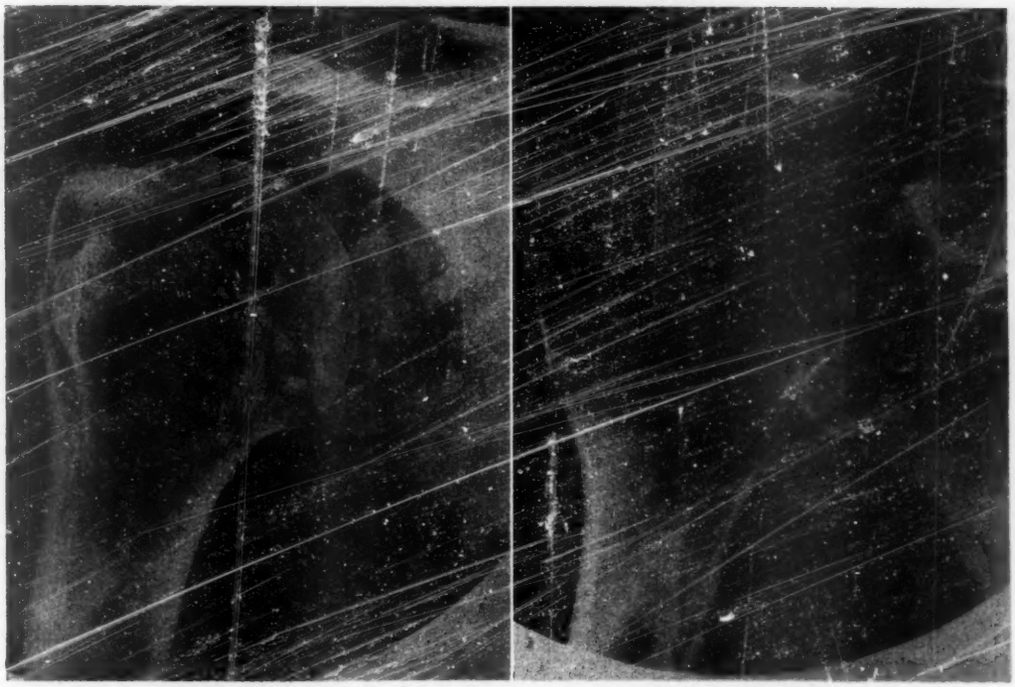
I. CALCIFIC TENDON DEPOSITS AROUND THE SHOULDER

For consideration in this section were 609 shoulders presenting deposits of medium or large size (Bosworth classification: small deposits less than 0.5 cm. in standard roentgen shadow, medium deposits between 0.5 and 1.5 cm., and large deposits greater than the last figure); and 887 similar cases of "tendinitis" accompanied by small or barely visible deposits. The smaller deposits have little clinical significance except as they are forerunners of larger deposits. Figure 1, which includes data on deposits of all sizes, emphasizes the widespread incidence of roentgen shadows due to calcium in shoulder disorders of all types. Indeed, these data probably underestimate the presence of calcific foci.

SPECIAL ROENTGEN TECHNIC; MULTIPLE CALCIFIC DEPOSITS; LIFE CYCLE OF THE DEPOSIT

The use of special roentgenographic methods, as the short focal spot with magnification [1] with or without intensification technics, will demonstrate many and widespread calcific foci not shown by the routine roentgenographic methods. Figure 2 is an example, routinely diagnosed as a single deposit in the subscapularis tendon. Special technic demonstrated eight foci of calcification.

Indeed, special roentgenographic technic is a more sensitive indicator of calcium deposition (and the accompanying tendon necrosis) than surgical exploration. The multiplicity of surgically significant calcific foci is unappreciated by many, as this point has received little attention. In this series of 104 cases (Table III) treated by direct surgical excision, eighty-two (78.8 per cent) had two separate deposits



2A 2B

FIG. 2. Short focal spot roentgenograms with magnification in external rotation (A) and internal rotation (B). Calcific foci are demonstrated in all rotator tendons and in the stump of the tendon of the long head of the biceps. Pain was localized to the subscapularis, the injection of which with hydrocortone-cyclaine gave relief of pain and disappearance of this shadow in seven days. The patient and the roentgenogram call attention to the degenerative arthritis of the acromioclavicular joint (exostoses and subchondral cysts), which was asymptomatic. (Roentgenograms courtesy of Dr. Martin S. Abel, San Francisco, California.)

larger than 0.5 cm. while twenty-four (13.7 per cent) had three or more such deposits. (Figures 2, 3A and 3C.)

Repeated observations on the same and different patients, and study of the roentgenograms covered by this report, at all stages and in all clinical states, both asymptomatic and symptomatic in various degrees, allow formulation of a concept of the behavior and effect of calcific deposits. This paper does not present any data on the totally asymptomatic calcium deposit since every person of this series was seen as a patient with shoulder complaints.

Many otherwise normal persons, chiefly young and early middle-aged adults, do carry asymptomatic calcific deposits in their shoulder tendons. An estimate of 1 per cent asymptomatic incidence in persons of both sexes between the ages of twenty-five and forty-five years appears warranted. Bosworth recorded 2.7 per cent, chiefly female office workers, symptomatic and asymptomatic. Calculation based on known incidence of the diagnosis producing symptoms among adults of more than twenty years in the Kaiser Foundation Health Plan is 0.3 per cent. No significant sex distribution was noted. The median age of persons with calcific deposits of the patients in this

TABLE III
TREATMENT FOR CALCIFIC ROTATOR CUFF TENDINITIS (609 SHOULDERS)

Treatment	No. of Cases
Needling after local injection of anesthetic drugs	135
Needling after local injection of hydrocortone, meticorten-anesthetic drugs (8 cases later had excision)	263
Excision or evacuation of calcific deposits and necrotic tendon fibers (both shoulders in 16 cases)	104
Roentgen therapy (28 later had excision on recurrence of pain or initial failure to relieve)	79
Rest, balanced traction-suspension and massive hot packs	28

FIG. 3A. Representative type of deposit in the rotator cuff tendons of the shoulder. Multilocular dry granulonodular deposit in the rim region of the infraspinatus tendon.

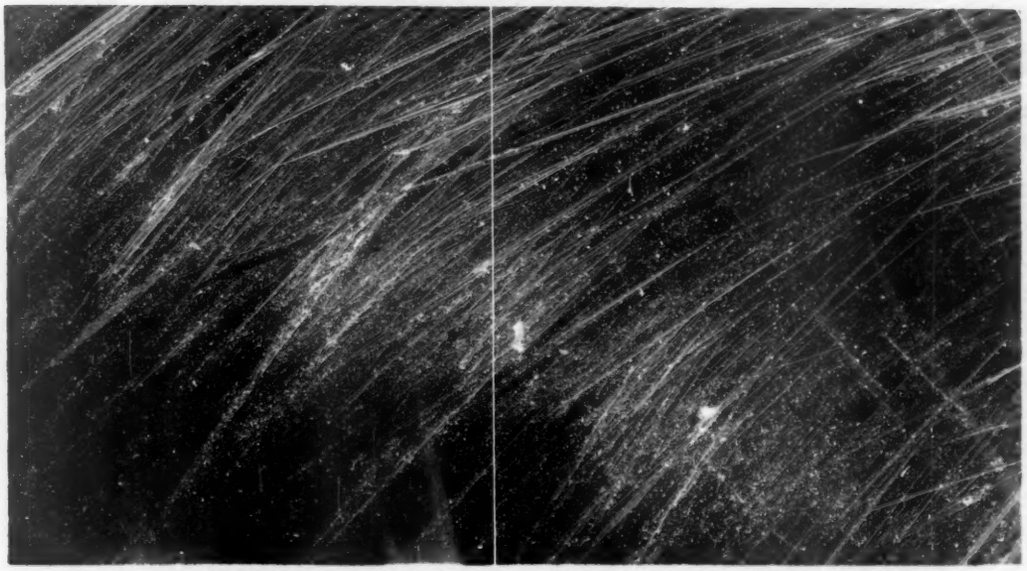
FIG. 3B. Representative type of deposit in the rotator cuff tendons of the shoulder. A large acute "chemical abscess" in the supraspinatus tendon ruptured and walled off in the bursa. This shoulder was a "hot" joint immobilized by pain. Inferior subluxation of the humerus is demonstrated.

FIG. 3C. Representative type of deposit in the rotator cuff tendons of the shoulder. Multilocular deposits (eight separate foci) in the supraspinatus and infraspinatus tendons. Two of these deposits were "chemical abscesses" demonstrating signs of acute inflammation.

report was forty-four years, ten years younger than the median for patients with frozen shoulders.

The details of the gross and microscopic alterations in the tendons are similar in cases with (1) no routine roentgenographic calcium shadows, (2) restricted or small calcium shadows and (3) larger granular deposits, and are contrasted as all having less severe acute inflammatory reaction than do patients with acute and fulminating symptoms associated with deposits. The gross and microscopic picture of the local lesion, as determined in all our open acute surgical cases of the fulminating type, was identical with that of acute focal inflammation in any soft tissue plus necrotic tendon fibers and a fluid or soft paste calcium deposit. While it is often said that there is variation in symptoms with apparently identical deposits in the routine roentgenogram (McLaughlin, Moseley and others), when "apparently identical" deposits are examined by detailed magnified roentgenograms obtained by the short focal spot-magnification technic, this concept is no longer tenable. A correlation exists in that the deposits having a granular texture (which at operation are dry and often powder-like) cause few or no symptoms, while those of a homogenous large shadow are correlated with subacute or acute symptoms. At operation these latter are under tension. (Figs. 2, 3 and 4.)

Few quiescent or little symptomatic deposits disappear spontaneously (based on serial observations at six-month intervals for three



4A 4B

FIG. 4. A, slightly external rotational view of a subacute large semi-fluid calcium deposit in the medial lower infraspinatus tendon. B, shift of the deposit in a medioposterior direction with extreme external rotation of the shoulder. This inaccessible deposit in the infraspinatus required partial acromion resection and detachment of the posterior deltoid for exposure.

years in thirty cases). Acute and hyperacute deposits (Table III) in twenty-eight patients, all medium and large deposits, disappeared in fourteen days, mostly in seven days (twenty or 71.4 per cent) on a regimen of ice bags, rest and balanced traction-suspension. However, the duration of acute symptoms with muscle spasm was greater (average ten days) than in 80 per cent of 104 surgical cases (average, three days).

TREATMENT OF CALCIFIC DEPOSITS

The measures that were used in the treatment of the entire group are summarized in Table III. Needling procedures were based upon localization both by roentgen shadow correlated with local tenderness. The former was the chief reliance in the chronic cases. Four hundred ninety-six cases were subjected to approximately 750 separate puncture or needling procedures (including eighty-four shoulders later subjected to open excision). Attempts to aspirate the deposit completely through a large bore needle (Patterson and Darrach, and Lapidus) were abandoned after variable degrees of effectiveness, all many years before the present cortone suspension era. During the last four years a total quantity of 2 to 4 cc. suspension, half of 1 per cent xylocaine or cyclaine® and hydrocortone (25 mg./cc.) or prednisolone (25 or 50 mg./cc.), has been injected into multiple sites just proximal to the greater humeral tuberosity, selected by tenderness and the roentgenogram; finally a portion of the suspension has been injected into the juxta-articular zone of the tendon of the long head of the biceps. Repeated needle punctures of the tuberosity tendons were done. Similar measures have been applied to cases of "tendinitis" without calcification.

Clinically excellent results were finally obtained by this method alone with disappearance of symptoms in fourteen days or less after the last injection in 314 shoulders (78.9 per cent of the whole group). Two hundred sixteen shoulders (54.3 per cent) required two or more injections. There was no difference in these percentages when cortone® suspensions were used. The impression which was not subject to statistical analysis was that there was less pain and less need for sedation procedures (physical and drugs) with the use of cortone drugs. A radically decreased incidence was noted in severe muscle spasm and milder degrees of periarticular stiffening when the cortone drugs were used (16.4 per cent compared with 66.6 per cent). Less clear-cut responses were obtained in asymptomatic and chronic cases than in those demonstrating significant or moderately acute symptoms. Extensive

regional infiltrations of local anesthetics and attempts to "irrigate the bursa" were observed to precipitate a prolonged troublesome frozen shoulder in seven cases arriving from other sources.

Direct surgical excision was carried out on 104 shoulders (17.0 per cent). Two classes of patients were selected for this procedure: (1) those in whom repeated (two to four times) needling and injections failed to relieve symptoms and cause disappearance of the calcium shadow, and (2) those with fulminating hyperacute symptoms. I consider this latter group a surgical emergency, and the relief is instantaneous upon incision of the large deposit under tension. The operation is carried out under local infiltration anesthesia of 1 per cent procaine through a 1 to 2 inch upper deltoid splitting incision. Division of the acromioclavicular ligament has never been done. As a rule (approximately 80 per cent of patients in whose cases insurance coverage is not a deterring factor) the patient leaves for his home immediately following the operation. In special cases (e.g., the patient in Figure 4) a more extensive surgical approach with acromial resection is needed for exposure.

In most cases (eighty-three or 79.8 per cent) full active motion is secured in three to five days in cooperative patients, and the incidence of a more prolonged convalescence was observed in only 20.2 per cent. Ease of exposure and non-extensive incisions in the tendons are factors favoring rapid and uncomplicated recovery. Extremes of three and four months until recovery were observed in two cases. Contrast the incidence of postoperative pain and stiffening following surgical excision (20.2 per cent) with that observed following injection of local anesthetics and needling (66.6 per cent). However, it should be pointed out that there were few cases that required more than thirty to forty-five days for full recovery in either group. It was not necessary to carry out an excisional operation in any case of calcific deposit in the subscapularis tendon, as none presented acute symptoms. All recovered following needling and sedation.

The coincident presence of large calcific deposits greater than 1.5 cm. in diameter and the frozen shoulder was first treated by operation or injection treatment for the calcific deposit, preferably the former. This is usually done under general anesthesia. In this special group a gentle manipulation of a few degrees is then performed followed by active and passive exercises in a few days when pain is not a deterrent. In twelve such operated cases, the period of full return of function was observed to be less than thirty days in eight (66.6 per cent).

Roentgen therapy for symptoms coincident with calcium in the rotator tendons was applied in seventy-nine shoulders. It is noteworthy that fifty-eight cases (73.3 per cent) received little or variable relief of pain, and twenty-eight of these cases later had excision of the deposit. Those slowly recovering after a variable length of disability demonstrated smaller (less than 5 mm.) calcium deposits in the roentgenograms. This experience, interpreted in the light of Plenk's observations (see page 528), contrasts unfavorably with the results from injections and excision operations. As a result, I discontinued the use of roentgen ray treatments eight years ago. We have been able to follow three instructive cases for three, four and seven years, respectively, who had received two, three and three courses of roentgen therapy, and who meanwhile demonstrated enlargement of the calcific deposits to two to five times their original size.

SUPRASPINATUS TENDINITIS (887 CASES)

Chronic cases with small deposits (less than 5 mm.) were included in the clinically poorly defined group of "supraspinatus tendinitis" (called by some the abduction syndrome). The group is defined by temporary variable loss in abduction power but chiefly pain on active abduction without any loss in passive motion. There were few acute cases (twenty-one, or 2.4 per cent) and since all these latter demonstrated small, poorly defined calcific shadows, they were interpreted as being either acute calcific tendinitis with rapidly absorbing deposits and were treated by rest, hot or cold applications and sedation. In the absence of arthrography, many small tendon ruptures were undoubtedly included, but the clinically more severe cases of this syndrome (selected by failure to recover active abduction after three to four weeks' observation and failure to regain significant power after anesthetic infiltration of the tuberosity) were properly submitted for repair (forty-four cases).

The remaining 866 cases (97.6 per cent) were not analyzable according to any special

response to any single method of treatment. Injections into painful areas in and around the biceps tendon of local anesthetics with and without cortone suspensions, followed by needling, diathermy and other forms of heat, ultrasonic applications, variable rest and variable use of sedation, were the methods used. Twenty-six cases (3.0 per cent) demonstrated such persistent symptoms and definite findings (more than four to six months) that they were subjected to acromial resection including acromioclavicular joint removal. All were improved and twenty of this group (76.9 per cent) were free of all symptoms on a one- to three-year follow up. The follow-up study on a 200 case sample of those treated with injections and needling indicated that more than 80 per cent of this group had complete or almost complete relief (see following section on follow up). No clear-cut difference was noted in the shoulders receiving cortone suspensions except less pain and stiffening. The diagnosis of supraspinatus tendinitis and/or biceps tendinitis was made in seventy-eight patients who months or weeks later were diagnosed as having a typical frozen shoulder. These cases were treated by the methods outlined under that category but not included in the statistics of that section. In many of these cases small calcium shadows were present, and the opinion is offered that small calcific foci are of no significance in treatment.

FOLLOW UP ON PATIENTS WITH CALCIFIC DEPOSITS AND "TENDINITIS" WITHOUT CALCIFICATION

Follow-up visits, six months to two years after cessation of successful injection-needling treatments, were recorded in seventy cases of medium and large size calcific tendon deposits in which only local anesthetic drugs were used, and in 206 similar cases in which the cortone drugs had also been injected simultaneously. Two hundred twenty-four (81.1 per cent) had no symptoms and a full range of shoulder motion. The remainder (18.9 per cent) had minor symptoms of aching after a hard day's work and with weather changes. Roentgenograms were obtained in forty-six (88.5 per cent) of this latter group. All demonstrated small granular calcium shadows signifying incomplete disappearance or new minor calcifications.

Periodic and regular follow up was maintained upon ninety-two shoulders in eighty-three patients following deposit excision for periods varying from six months to eight years after discharge from active care (over two years in eighty shoulders of seventy-four patients, 87.0 per cent). Roentgenograms were made every six months for two years and at one to two years thereafter. In no case in which complete initial removal of all the deposit(s) was obtained was there noted any increase or redeposition of calcium elsewhere except in a single case in which deposit in the contralateral subscapularis developed five years later.

Although we were able to secure follow-up visits one to three years after termination of treatment in a 200 case sample of tendinitis without calcification (with result of 80 per cent relief in the group), the statistics do not tell the whole story as difficulty was experienced in obtaining such attendance, and the number of patients who were lost suggests less satisfactory results in this group. That twenty-six acromion resections were performed in this group and none in the group of calcific tendinitis with large- and medium-sized deposits would also tend to confirm this impression.

II. THE FROZEN SHOULDER: PATHOLOGY AND FUNCTIONAL PATHOGENESIS

In both the severe idiopathic type and the less severe secondary cases (Table II), there is limitation to some degree in all four joints of the shoulder complex including the two clavicular joints. While the glenohumeral joint suffers most and the scapulothoracic joint the least, the effect is widespread and ataxia and muscle atrophy results. At this stage in our knowledge cause and effect are separated with difficulty. It is difficult at times to place a single frozen shoulder into a primary or secondary classification. It is probable that many secondary conditions play a simultaneous role in causation in a single patient. Secondary cases in which a single anatomic causative factor can be discovered tend to be milder and to yield rapidly upon removal of the cause. If painful arthritis of the acromioclavicular joint is treated by excision of the outer 1 cm. of the clavicle or by acromion resection including the joint, rapid recovery is seen in the second month.

Since the frozen shoulder develops almost entirely in persons between forty-five and sixty years of age, the widespread degenerative

changes of ligaments and tendons of all four of the joints around the shoulder play a role. In the fully developed condition a thickened, tightened, friable and inelastic glenohumeral joint capsule is seen, and the normally free inferior capsular pouch is obliterated. There

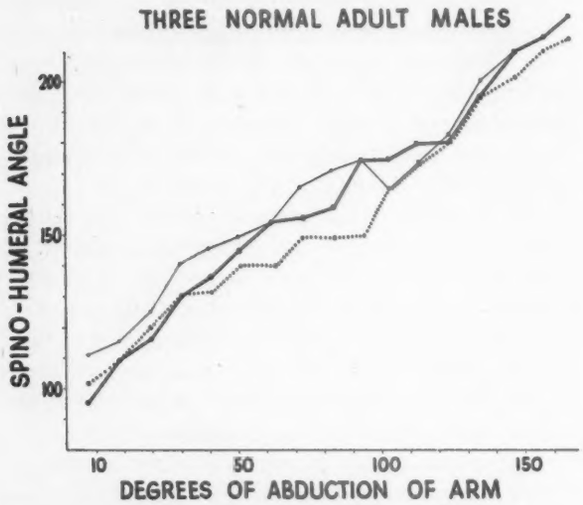


FIG. 5. The straight line relation of the angle between the scapular spine and the humeral axis (spinohumeral angle) in abduction in three normal adult males. This signifies non-ataxic elevation of the upper extremity with simultaneous participation of the two bones.

is a relative absence of fluid within the joint and the bursal walls are pale and atrophic, these latter the effects of disuse. On careful manipulation, the anterior joint ligaments, the anterior joint capsule itself and the intra-articular portion of the biceps tendon give way with a palpable and audible snap, followed by peeling of the capsule from the humeral head (Neviaser and McLaughlin). Only when vigorous "full range" manipulation is carried out is the subscapularis tendon likely to be avulsed. Subscapularis avulsion is undesirable, while intra-articular biceps tendon avulsion seldom leads to sequelae as the distal segment is retained in the biceps groove.

The microscopic examinations (Neviaser, McLaughlin) show increased vascularity with cellular proliferation, and collagen degeneration and proliferation. The synovial and subsynovial layers show edema and focal inflammatory cell proliferation. It should be pointed out here that similar changes are found in the biceps peritendinous tissues. Many cases show only a minimal involvement of the biceps tendon and peritendinous tissues, and maximum involvement of the capsule including the coracohumeral and the glenohumeral ligaments.

The evidence of contracture and inelasticity of the glenohumeral joint capsule is clear, and consists of data from:

1. Physical examination: Loss of abduction

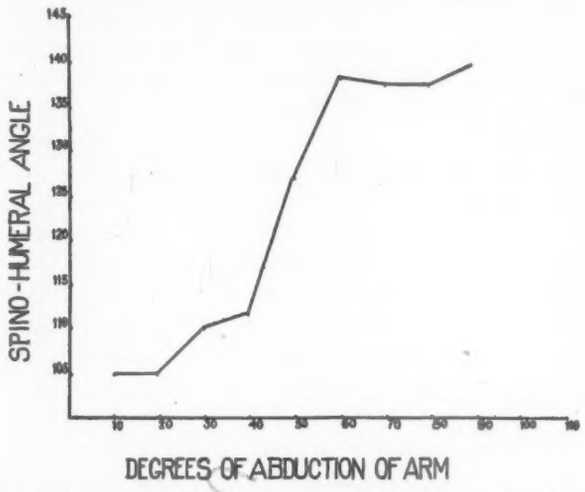


FIG. 6. The spinohumeral angle and limitation of abduction produced by temporary fixation of the acromioclavicular joint by two transverse screws. Note normal abduction to 40 degrees, exclusive elevation of the humerus to 60 degrees while the last 30 degrees of abduction is scapulothoracic motion. This ataxic abduction is reminiscent of the frozen shoulder.

and lateral rotation of the humerus, and anteroposterior gliding motion of the humerus relative to the glenoid.

2. Roentgenograms, especially superior-inferior roentgenograms, demonstrate the lack of mobility of the humeral head in relation to the glenoid. (Fig. 7.)

3. Joint capacity studies with contrast media demonstrate a reduction of the normal 30 to 35 cc. capacity to less than half in the patient with frozen shoulder.

4. Surgical exploration allows a direct confirmation of the thickening and inelasticity of the glenohumeral joint capsule and its ligaments.

Although, in the adult, fusion of the rotator cuff tendons to the capsule is complete over a considerable distance, in infants and adolescents each of these structures is separable. The avascularity of the tendon structures of the adult, increasing markedly beyond age forty-five, and the inseparability and thus diminution of gliding surface, are factors that augment the degenerative changes that preceed the frozen shoulder.

FUNCTIONAL ALTERATIONS OF THE FROZEN SHOULDER

On gross examination, deltoid and other muscle atrophy is present, the deltoid effect being the greatest. Capsular adherence and inelasticity plus muscle atrophy with weakened power result in ataxia over the permissible range. Ataxia plus the inelastic joint capsule and blocking against the acromion with pain result in observed lack of motion. The muscular phases can also be demonstrated by electromyograms, where dysrhythmia and low voltage is evident. Anatomic restriction of motion is always far less than that active and passive motion in the non-anesthetized patient. The effect of pain and reflex muscle spasm inhibiting motion makes motion ranges difficult to estimate exactly. The aim of the therapist is to reverse these trends by stretching, and by increasing the strength and co-ordination of muscular function in the whole area. The over-all picture in the frozen shoulder has some functional similarities to the effect of nailing the acromioclavicular joint. (Figs. 5 and 6.)

In the frozen shoulder, humeral abduction on the glenoid occurs little or not at all and mobility of the humeral head relative to the glenoid, coracoid and acromion is disturbed. This latter effect is portrayed on physical examination and in the superior-inferior roentgenograms (see Figure 7). In both abduction and extension* (forward elevation) the acromion covers more of the humeral head in the frozen shoulder due to the inelastic capsule preventing anterosuperior displacement. The acromion also covers more of the head on side abduction than elevation in any forward direction. The usual assumption of the 45 degree anterior direction of the glenoid face relative to the humeral axis is prevented in the frozen shoulder, and the humeral head is caught as in a vise between anterior capsule and ligaments and the coracoacromial axis. The acromion itself is unyielding and in some persons abutment of the greater tuberosity against the coracoid occurs.

* In this paper extension is used in the sense of the usual definition and as used in comparative anatomy signifying forward elevation in the sagittal plane. Abduction (at the side) is self-explanatory. Intermediate positions of elevation are related to sagittal plane elevation from abduction as "degrees into the sagittal plane."

FIG. 7. Superior-inferior roentgenogram of a patient two months after acromial resection when he was able to actively abduct to 155 degrees (abduction before treatment, 30 degrees). Abduction at side view. The factors that have allowed restoration of active motion in addition to increased muscle strength to be observed in this roentgenogram are restoration of the anterior displacability of the humeral head and removal of the mechanical and irritative effects of the acromion and the acromioclavicular joint.

NORMAL FUNCTIONAL ANATOMY OF THE SHOULDER

A full description and understanding of all the phases of shoulder joint function has not as yet been formulated, and Codman's statement [10] is a written expression of the complexity of this joint. ". . . it is quite possible that by astronomical calculation from motion picture x-ray film of a living skeleton, the relativity of these compound motions might be made out . . . calculations for the motions of the spinal column must be added . . . it is scarcely possible to move the shoulder without compensatory curving or twisting of our spines. This is particularly true in patients with sore shoulders."

In the normal adult the semi-elastic glenohumeral joint capsule with its reinforcing anterior ligaments, plus the tightly adherent musculotendinous cuff, are the elements responsible for the stability of this joint. The tension supplied by the axiohumeral muscles and the scapulohumeral muscles, particularly the pectoralis major, the deltoid, the rotator cuff muscles and tendons, and the teres major and latissimus dorsi further reinforces the ligaments and capsule. Free, unimpeded synchronized motion of the humerus in almost a full arc, relative to the trunk, is possible.

The characteristic of the frozen shoulder is impedance of motion at the upper humerus,

particularly above 60 degrees' abduction and 90 degrees' extension (forward elevation), especially noticeable at the glenohumeral and acromioclavicular joints.

Two degrees' motion both in frontal elevation and abduction occurs at the normal glenohumeral joint to each degree at the scapulothoracic joint after 30 to 60 degrees' initial range are passed [22]. This point is also approximately the critical point of abduction blockage of the arm for the frozen shoulder, the initial 30 to 60 degrees there being chiefly scapulothoracic. The abduction rhythm is therefore lost. Little attention has been directed to either the acromioclavicular or the sternoclavicular joint in the pathogenesis of the frozen shoulder, but degenerative arthritis of both these joints is common.

The acromioclavicular joint [22] allows elevation of the clavicle through a total range of 20 degrees, the motion occurring both early and in the terminal phases of abduction. The sternoclavicular joint moves 4 degrees for each 10 degrees' elevation of the arm during the first 90 degrees. The incidence of degenerative arthritis at the acromioclavicular joint (combined physical and roentgen diagnosis) has been 60 per cent in our series of frozen shoulders, while involvement of the sternoclavicular joint has been less than 5 per cent. The implications in excision of the acromioclavicular joint with acromiectomy now become clear (see page 540). The anterior displacement of the greater humeral tuberosity in abduction (*vide infra*) and the temporary blocking effect of the acromion and coracoacromial ligaments on abduction are not fully appreciated. The normal 45 degrees' anterior direction of the glenoid in abduction and forward elevation are important in normal motion. When rotation and anterosuperior gliding of the humeral head are prevented by the tight capsule the greater humeral tuberosity also impinges against the coracoid process, at least in some cases.

The last mentioned relations to the acromion were formulated long ago by Codman: "When the arm is carried as far forward and upward as possible in the sagittal plane, the entire humeral head, tuberosity and all, disappears beneath the acromion. But if the arm is elevated in the coronal plane it will have to be rotated outward to attain complete elevation."

The necessity for normal muscle strength and co-ordination for full shoulder motion was appreciated by Codman: "It is dependent for its accuracy of motion in every direction on a group of muscles which must be absolutely co-ordinated and always work together . . . Moreover, each muscle must be prepared to substitute for a neighbor in case of slight injuries or all together to go on strike until the injured one is healed."

TREATMENT METHODS AND RESULTS

Prevention of the frozen shoulder is important. The exercises and directions for this purpose are well known and will not be repeated here. Codman himself admitted discouragement when he stated: "This is a class of cases that I find difficult to define and difficult to treat."

The particular symptoms and diagnosis of the frozen shoulder depend upon the lack of both active and passive motion with the scapulothoracic joint allowing the remaining motion. Osseous atrophy, small tuberosity cysts and irregularity and sclerosis of the greater tuberosity shadow in roentgenograms are an expression of dysfunction on the one hand and of long-standing rotator tendon attrition including possibly small repeated tears. The importance of superior-inferior roentgenograms to replace or supplement the generally non-informative and confusing lateral views taken through the chest cannot be overemphasized, as many a posterior dislocation has gone unrecognized for lack of such views.

Over the years covered by this study there has been some variation in the methods of treatment and some change in concepts. At first it was not appreciated that in some persons, especially the insidiously occurring type of middle age (idiopathic), the frozen shoulder goes through definite phases of (1) "freezing," (2) stationary status with relief of pain but with maximal motion limitation, and (3) "thawing" with slow resumption of motion. The duration of the first phase is variable and in many persons the stationary phase with dull aching and little scapulohumeral motion may persist indefinitely without treatment. Active measures during the first phase are discouraging to both patient and physician. For this reason it is difficult to compare the results of exercises, the scope of which is limited by pain and the lack of patient drive, with the results of a properly conducted manipulation(s) under

anesthesia followed by exercises. The patients who will permit manipulative and other definitive measures are usually better motivated. I feel that the proper field for manipulations under anesthesia is in phases 2 and 3. If the patient is far advanced in the recovery phase, manipulations are probably unnecessary unless progress lags for more than two to four weeks.

TABLE IV
TREATMENT FOR 803 FROZEN SHOULDERS*

Treatment	No. of Cases	Percentage
Physical treatments	367	45.7
Manipulation under anesthesia	436	54.3
Surgical exploration with division of soft tissues	8†	1.0
Excision of the acromion including acromioclavicular joint	30†	3.6
Resection of the distal 1 to 2 cm. of clavicle	8†	1.0

* Seventy-four (9.3 per cent) were bilaterally involved shoulders in the same patient.

† These patients all had preliminary physical measures or manipulation under my supervision. There were other patients (see page 540) on whom excision or resection was performed after the preliminary treatments had been given elsewhere.

The measures directed at the frozen shoulder aim to restore active motion and abolish the ataxia resulting from depressed muscle function, by active and passive motion, aided at times by electrical stimulation. The effect of injectable corticoids has been inconstant and I do not now use them. Aspirin and buffered aspirin are used freely. Hot packs, infrared and other measures to supply heat and suppress painful muscle spasm precede mobilizing exercises. It should be pointed out that the personality and personal cooperation obtained between therapist and patient, and between the doctor and the other two members of the team, is very important. It is the failure to obtain this cooperation which has caused some observers to refer to the "periarthritic personality," an effect of frustration and ineffective treatment rather than being basic with the patient.

At the present time, as shown in Table IV, slightly less than half the patients with frozen shoulders progress well with active and passive motion under the guidance of a therapist. Treatment should not be started until the pain of advancing freezing is reduced. The disregard of the painful early stages results in increased pain and prolongation of disability. Then, or at almost any phase in the secondary types, manipulation of the shoulder under anesthesia is carried out. If a stationary phase lasting more than two weeks is reached, manipulation is performed.

TABLE V
LATE FOLLOW UP ON THREE SEPARATE GROUPS OF 100 CASES EACH OF FROZEN SHOULDER TREATED BY MANIPULATION UNDER ANESTHESIA

Group	Date of Follow-up Study	Year of Cases	Per cent Having Full Painless Motion	Per cent of Persons Over Age 60	Per cent of All Cases Treated by Manipulation (same period)
I	1943–1944	1940–1941	82	26	82
II	1950	1947–1948	94	4	56
III	1954	1951–1952	64	33*	52

* Includes 18 persons who died from other diseases, chiefly cardiac, by the time the follow-up study was made.

The Technic of Manipulation. This is carried out with gentleness. No attempt should be made to obtain a full range of motion while the patient's pain perception is abolished with anesthesia, unless there is a sudden release and snap and the remainder of the range is immediately free. This phenomenon has been recently referred to by Quigley as the "checkrein shoulder." The effect is immediate and sustained normal motion easy to maintain. All other shoulders should receive repeated fractional manipulations, signifying in some cases several manipulations, gaining a few degrees at a time with exercises as tolerated. Few shoulders (4 per cent) have been manipulated more than twice during the past ten years (see indications for acromion resection, page 540). Prior to that time 10 per cent were subjected to three or more manipulations and the results were not as good. (Table v.)

An immediately beneficial effect of a balanced program of heat, active and passive motion and properly timed gentle manipulations is seen in 95 per cent of persons physically qualified who are not pushed during the acute phases. Within 15 to 20 degrees of full vertical

abduction and less than 25 per cent deficit in external rotation are obtained within two months (often sooner) in 90 per cent of those demonstrating sudden release and no impedance in the higher ranges at manipulation. Those failing to show this reaction to manipulation have greater postmanipulative pain and spasm and respond only to a modest degree to subsequent exercises. These are the cases that require three to six months or longer (approximately 20 per cent of the total) to gain the standard of recovery just described. An appreciable fraction (half) of those demonstrating the sudden release phenomenon maintain the aforementioned standard of recovery within two weeks of the manipulation. The most rapid recovery was three days. The immediate results regarding full range four to six months after manipulation are better than those from the follow-up study. This is appreciably affected by the percentage of persons beyond age sixty and by the infirm. (Table v.)

Quigley's results are about the same as mine, with 75 per cent maintaining full motion on a two-month to four-year follow-up, with the remainder "improved in varying degrees." Results in these two series of cases are greatly improved over those already reported in the literature [*14,46*]. Withers [*52*] reported "full recovery in all in two weeks to four months" in forty-one "quiescent" patients treated by the same methods.

A separate small group of thirty-two patients were treated by preliminary hospitalization for two to four days, either tying the splinted forearm to the head of the bed (fourteen cases), as recommended by Codman, or placing the arm and forearm in balanced traction-suspension. Both these groups of patients had less postmanipulative discomfort and maintained motion better. At one month twenty-eight patients (87.5 per cent) had achieved the recovery standard previously described. During the early years of this study the wrist was tied loosely to the head of the bed in ninety-one instances. Except for the patients of the first follow-up study (Table v), most of the remainder were treated as ambulatory outpatients because of the factors of time, employment, lack of hospital facilities, etc.

It is difficult to compare the results of careful manipulative procedure followed by exercise with the latter measures alone, but some observations made upon twenty-five cases during 1949, treated by hot, moist packs and/or infrared exposures and exercises, applied in cases of the "idiopathic" type, are available for comparison to results observed in manipulations demonstrating the release phenomenon. No case of this non-manipulative series attained the previously mentioned standards of abduction (160 degrees) in less than six weeks; at two months only 20 per cent had arrived at this point and the median period for all twenty-five cases was four and a half months.

SURGICAL MEASURES IN FROZEN SHOULDERS

In eight cases, during 1948, exploration of the anterior capsular region with division of the capsule including anterior ligaments and excision of the intra-articular part of the biceps tendon was done with manipulations under direct vision. The Neviaser-McLaughlin findings were confirmed except that the subscapularis tendon which had been elevated as carefully from the capsule and as far distally as possible did not suffer. The rate of recovery was the same as that for satisfactory "snapping" manipulative cases, except in two in which an intractable stiffness developed. This was prior to acromion resection and these two cases and the experience that nothing appeared gained as far as time was concerned caused us to give up the method.

Acromial resection including the acromioclavicular joint* was carried out in twenty-six cases prior to 1955. In four earlier cases the distal 1.5 cm. of acromion was excised short of the joint. There were six additional patients who have been operated upon during the past year who had either had many months or years of adequate exercises and/or manipulations elsewhere. Our thirty cases were selected from patients who were physically vigorous and had reached a stationary phase with less than 100 degrees' passive abduction in recovery following manipulation. In all thirty-six of these cases active abduction to 160 degrees or more

* Both Armstrong and Watson-Jones recommend including the acromial face of the acromioclavicular joint and sufficiently wide removal of the acromion in the posterior juxta-articular region so the clavicle can move unimpeded. Their cases were the painful "abduction syndrome" (not the frozen shoulder). Apparently, neither of these authors excises the acromion for the frozen shoulder, and they omit reference to their further treatment (if any) from the failure of exercise in this latter condition.

was achieved by three months postoperation and in two months by most (twenty-eight or 77.7 per cent). The rationale for acromion resection is not only the relief from local pain and the pain from acromioclavicular degenerative arthritis but also the removal of the osseous mechanical block of the acromion effected by the non-elastic joint capsule of the frozen shoulder. The factors of proper centering of humeral head against the glenoid face are illustrated in Figure 7.

Ten resections of the distal 1 to 1.5 cm. of clavicle were performed (eight patients having previously received conservative treatment) under the indication of continued pain localized to the acromioclavicular joint which seemed to be the important deterring factor in obtaining or maintaining active abduction beyond 100 to 120 degrees during the recovery-exercise period. The relief from pain and ability to maintain near normal active abduction within a month was noted in all.

ADDITIONAL MEASURES FOR THE RELIEF OF PAIN

To supplement the measures already described we have used the ethyl chloride spray [25], and various types of nerve blocks with procaine or other local anesthetics (suprascapular, partial brachial and stellate ganglion). The proper application of the ethyl chloride spray (two or three directions and fifteen to twenty minutes' time) is too time-consuming and costly, but is quite effective in aiding active exercise against the partly mobile shoulder. Nerve blocking has a place during various acute days. However, for routine use various simple means of supplying heat or cold and the use of aspirin or empirin® suffice for most patients.

SUMMARY AND CONCLUSIONS

Accurate records and sufficient data were available on the treatment of 2,580 painful shoulders, of a total of more than 5,000 cases, for analysis. A detailed analysis of 803 frozen shoulders, 609 shoulders with "medium" and "large" calcium deposits (greater than 5 mm. in greatest roentgen shadow) and 887 shoulders characterized by abduction pain, tuberosity tenderness and no loss of passive motion (labeled as supraspinatus tendinitis) is presented.

Excellent results (abolition of pain and restoration of motion) were obtained within fourteen days in 78.9 per cent of 314 shoulders with calcium deposits treated by injection of local anesthetics and/or cortone drug suspension and followed by needling. There was no difference in the recovery rate in those receiving the cortone drug suspensions, but the incidence of pain and immediate loss of motion was four times as great in those receiving local anesthetics only (16.4 per cent as against 66.6 per cent). Follow-up on 276 cases six months to two years later demonstrated maintenance of recovery in 81.1 per cent of this latter group. The treatment of small- and medium-sized granular deposits in patients with chronic symptoms was unsatisfactory by the injection method in a significant percentage.

Serial roentgen ray studies at two- to three-day intervals on shoulders following the needling procedure and in acute cases treated by rest and sedation showed that the vast majority of such troublesome deposits disappeared in seven to fourteen days, some sooner. Serial roentgen studies at six-month intervals for three years on thirty cases show that few quiescent deposits disappear spontaneously (none in this group).

Frozen shoulders with large calcium deposits are best treated by excision or needling of the calcium deposit prior to measures to increase motion. Similar frozen shoulders with medium- and small-sized calcium deposits are treated to restore motion without regard to the calcium deposits.

Surgical excision is indicated as the treatment of choice for quickest and most uncomplicated recovery in acute and hyperacute large and medium calcium deposits. These are chemical abscesses and the immediate relief following evacuation under local anesthesia as an ambulatory patient is gratifying to both patient and surgeon. Full active motion through almost full range was obtained in 79.8 per cent of 104 shoulders in three to five days. Only two cases of this group exhibited prolonged recovery times (three and four months). Surgical excision is also indicated in medium and large granular deposits giving very chronic symptoms, as the response to injections is not percentagewise as good as in persons with subacute and recurring symptoms. Large hyperacute deposits disappear without excision but there is time lost in recovery and the patient suffers more.

Roentgen ray treatments in this experience had no demonstrable effect in calcific tendinitis not explainable by rest and/or exercise and sedation. Controlled studies by other authors establish the non-effect of roentgen ray treatment beyond question. We observed three remarkable cases in which the calcific shadow enlarged threefold during repeated roentgen treatments.

The frozen shoulder syndrome contains primary and secondary types but the discovery of causative and prolonging factors is at times difficult and uncertain, and causation is multiple in many. Exercises and manipulations are effective in restoring motion especially in the "snapping response" to gentle manipulation. Many frozen shoulders respond to exercises in physically vigorous and motivated patients.

The essential pathology of the frozen shoulder results in a leathery, friable and non-elastic shoulder capsule which prevents abduction, rotation and free application of humeral head to glenoid at the precise degrees of rotation and abduction. Muscular atrophy, ataxia and pain together with dysfunction at the coracoacromial axis also play a role in maintenance of stiffness.

In this series 54.3 per cent of 803 shoulders were submitted to gentle manipulative treatments under anesthesia. Immediately beneficial results with motion maintenance were observed in 90 per cent of cases in which there was sudden snap and release to full passive range. Such a result was definitely accelerated in time in comparison to the follow-up study in a small group carefully observed and receiving only physical measures and exercises. Three separate follow-up studies two to three years after manipulation showed full painless motion in 64 to 94 per cent of cases, the lower percentages being associated with a higher incidence of persons beyond sixty years of age and in cardiac patients. Physical treatments and exercises gave excellent results after a more prolonged time in two-thirds of 45.7 per cent of the entire group. Manipulation under anesthesia is indicated after it is demonstrated that recovery with exercises is progressing slowly or if an adequate program of exercises has been given or as initial treatment in the stationary phase. Manipulation followed by exercises is the treatment of choice in that stage of the frozen shoulder. Together, these non-incisional measures were effective in an estimated 90 to 95 per cent of persons not handicapped by infirmity or cardiac disease.

Acromion resection including at least one face of the joint is a valuable direct method for (1) relief of pain in persons with prolonged painful abduction syndromes and (2) relief of pain by allowing increased motion in stubborn cases of the frozen shoulder. Excision of the outer 1 to 1.5 cm. of the clavicle is also effective in persons when painful acromioclavicular joints are an important factor in the frozen shoulder.

The doctrine of self-limitation in the two disorders considered has been responsible for a non-energetic attitude and lack of detailed study of patients. Symptomatic relief and shortening the over-all period of disability and certain recovery with minimal residuals appears effected under the following circumstances: (1) medium- and large-sized granular calcium deposits with chronic and intermittent symptoms submitted to excision, (2) acute and hyperacute calcium abscesses submitted to excision, (3) other deposits injected, aspirated and/or needled with local anesthetic-cortone suspensions, (4) frozen shoulders in the stationary phase submitted to preliminary traction or stretching followed by gentle manipulation under anesthesia which respond by a "snap" and an immediately observed full passive range, and (5) prolonged painful "abduction syndrome" shoulders and otherwise non-responding frozen shoulders submitted to acromial excision including a portion of the acromioclavicular joint. The common denominator in recovery from the frozen shoulder is motivation and physical capability to stretch, actively exercise and withstand a certain amount of physical discomfort since increased functional demand is the only agent known at present that will restore the inelastic joint capsule to a more resilient state. It follows that some or all the methods described herein may be unnecessary in a specific patient as this report deals with the majority.

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The Problem of Minor and Major Causalgias

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Causalgia is described as a distinct clinical entity by Boyd [3]. This is corroborated by White and Selverstone [16] and the diagnosis depends on the following factors: "1. The appropriate injury of a peripheral nerve. 2. Diffuse burning pain, paroxysmal in character and aggravated by disturbing the patient's environment. 3. Temporary relief by blocking the regional sympathetic ganglia with procaine and permanent benefit following adequate sympathectomy." The term causalgia was introduced by Mitchell [10] in 1864 to describe, rather than to name, a somewhat bizarre symptom complex characterized chiefly by a severe burning pain in an extremity which suffered injury to a peripheral nerve. Major causalgia should include only cases of intense pain, burning in character, radiating diffusely up the injured extremity, and often brought on by extremes of temperature and psychological stimuli. Serious causalgias are seen chiefly in war and are apt to follow wounds of great nerves. The median and sciatic nerve injuries are responsible for most of this type of pain as found in the series of Barnes [1], White and Selverstone [16] and Shumacker [13]. The incidence of major causalgia in war wounds is 2 to 5 per cent, as found by Mayfield and Devine [8] and Ulmer and Mayfield [14]. Barnes [2] states it has not been possible to estimate the true incidence of causalgia, but agrees that it is not a frequent complication of the peripheral nerve injuries of warfare. Major causalgia [9] presents a picture of a disabled extremity, reddened, glossy, edematous, cool, with burning pain, sore to touch, intolerant of dryness, and sensitive to drafts and jars. The bones may be demineralized and muscles are atrophied or seem to be partly paralyzed.

Cases seen in civilian practice are variations as to the type of injury and type of pain, and are not as clear-cut as causalgia of war wounds. Many are of the minor causalgia type. Homans [4] introduced the term "minor causalgia" in 1940, and described it as a disagreeable phenomenon of lesser importance and greater frequency than major causalgia, manifested by unpleasant sensations and pain on use or pressure. Nathan [11] referred to these sensations as "pins and needles pain" and found an incidence of 14.4 per cent in 160 cases. Posch and Larsen [12] found four instances of minor causalgic pain in 204 patients with injuries to peripheral nerves seen in civilian life, or an incidence of 2 per cent. Many types of lesser injuries produce minor causalgia, such as blows, fractures, crushes, lacerations and puncture wounds. The trauma does not involve the great vessels and nerves as in major causalgia.

There are many varieties of burning pain which are poorly understood. These are related to the serious causalgias and can be found in the literature [5] by various names such as painful osteoporosis, reflex dystrophy, chronic segmental arterial spasm, Sudeck's atrophy, traumatic edema and others. Minor causalgias as described by Homans [4] show changes which include atrophy of bone, disorders of joints, edema, persistent hyperalgesia, paresthesia and vasomotor dysfunction. There is usually cool, smooth bluish skin, but occasionally vasodilation. All may appear together or in various combinations. There is underlying sympathetic irritability of central origin manifested by cold, damp, cyanotic hands and feet. The basic feature of all is pain. Livingston [6] has called these post-traumatic pain syndromes.

The cases presented in this study represent minor causalgias. They are private patients referred chiefly from industrial clinics for con-

sultation and treatment. The injuries incurred are a variety of those found in factory accidents as well as in daily civilian life. Almost all patients had burning pain and vasomotor dysfunction. This is the basis for their being diagnosed as having minor causalgias.

MATERIAL

Thirty-four patients with causalgia were treated by the authors during the past thirteen years. There were twenty-one men and thirteen women, from the age of eighteen to sixty-three years. Sixty-two per cent were in the fourth and fifth decades. The patients were seen from one month to eleven years after the time of the initial injury. The character of the injuries ranged from minor contusions and lacerations to severe crush injuries. In the group of thirty-four patients there were nineteen crush injuries, eleven lacerations and four gunshot wounds. None of the patients had complete severance of a nerve, and only four had injuries to large nerves such as the brachial plexus or sciatic nerve. The site of injury was the finger in fourteen cases, hand six, wrist four, forearm four, brachial plexus two, foot one, pelvis one, and knee two. The site of pain was confined to the hand or fingers in eighteen cases, and radiated diffusely from the hand up the arm to the shoulder in twelve patients. The pain was present in the foot and leg in four instances.

The character of the pain was as follows: In the nineteen crush injuries the pain was burning and usually constant but with spontaneous intermittent exacerbations. Five of the patients with crush injuries complained of exaggerated pain on using the part or when pressure was applied. There were exaggerated disagreeable responses to tactile or painful stimuli in seven of these nineteen cases. Some of the patients complained of sensory disturbances other than pain. In six there were paresthesias such as tingling, gross sensory loss as numbness in eight, and a feeling of coldness in four. The eleven patients with a cutting type injury complained of burning pain which was constant or intermittent. Three complained of painful exacerbations on use or pressure. Seven of these patients complained of tingling. Four had gross sensory loss such as numbness, and one had a feeling of coldness. Three of the four patients with gunshot wounds complained of burning pain which was spontaneous or intermittent. Two had hyperesthesias and two had gross sensory loss. Most of the patients thought the pain began within twenty-four hours after injury. There was onset of pain within five days to eight weeks in five cases. The others were uncertain as to the time of onset of pain.

There were trophic changes in twenty-nine of the patients. These consisted primarily of cold, shiny, sweaty extremities. However, there were three patients whose extremities were red, shiny and dry. Many of the cases were seen quite late following the injury and most had signs of vasoconstriction.

Eighteen of the thirty-four patients had neurotic manifestations. The twenty-eight industrial patients were receiving compensation from some source and had the possibility of a future financial settlement. The six private patients had legal suits pending for remuneration. This "recompense factor" made it most difficult to distinguish malingerers from those who were truly neurotic, and from those whose emotions were disturbed as a result of persistent severe pain.

TREATMENT

The thirty-four patients with causalgia were treated in various ways. One group of twelve patients received sympathectomy, and are tabulated in Table 1. Ten of these patients received temporary relief from procaine infiltration of the stellate ganglion. One received no relief from stellate block and one had no relief from lumbar sympathetic block. Prior to sympathectomy one patient received local infiltration of procaine into the painful area without relief. He also had an exploration of the elbow for epicondylitis without relief. In addition, eight other patients of this group underwent various operative procedures without relief before undergoing sympathectomy. An upper thoracic ganglionectomy with excision of the second and third dorsal ganglia was performed in ten cases. A thoracic preganglionic sympathectomy was performed in one case, and lumbar sympathectomy with resection of the second and third lumbar ganglia was done in one case. Six of the patients received complete lasting relief of their pain from sympathectomy. Four have partial relief and two have no relief. The follow-up period has been from four months to six years after sympathectomy. The time of injury to time of sympathectomy varied from one month to eleven years.

TABLE 1

TWELVE PATIENTS WITH CAUSALGIA TREATED WITH SYMPATHECTOMY

Case	Character of Injury	Elapsed Time before Sympathectomy and Symptoms	Surgical Procedures	Relief	Follow-up after Sympathectomy
1. W. P., male, age 49	Crushed 5th finger in car door	15 days; continuous burning pain in hand and finger; cyanotic, cold 5th finger	(1) Procaine stellate block	Temporary	2 yr.
			(2) Upper thoracic postganglionic sympathectomy	Permanent	
2. H. J., male, age 33	Struck elbow against wall	5 mo.; shooting sharp pain in hand up to elbow; sweaty, cold hand; tingling forearm; personality changes	(1) Procaine injections	None	5 yr.; 2 wk. after sympathectomy he developed hysterical inability to use hand and arm; has no pain
			(2) Arm in cast	None	
			(3) Elbow explored for epicondylitis	None	
			(4) 5 stellate blocks	Temporary each time	
			(5) Cervicothoracic ganglionectomy	Permanent	
3. C. L., male, age 43	Fan struck hand; compound fracture of metacarpals	5 yr.; burning, drawing pain in dorsum of hand; shiny, red, inflexible skin; personality change	(1) Procaine stellate block	Temporary for 2 mo.	5 yr.; complains of numbness; emotionally unstable
			(2) Upper thoracic ganglionectomy	Permanent	
4. J. C., female, age 63	Colles' fracture	3 mo.; burning pain with numbness of hand; shiny, reddened skin; marked osteoporosis	(1) Open reduction of Colles' fracture	Pain began 8 wk. later	4 mo.; has pressure sensation in hand; pain present but improved
			(2) Procaine stellate block	Temporary	
			(3) Upper thoracic ganglionectomy	Partial	
5. S. S., male, age 29	Cover of dishwasher fell on hand	4 mo.; burning pain with numbness of hand; thin, shiny skin; unable to move fingers or wrist except for slight flexion; personality change	(1) Immobilized by splint	None	4 yr.; poor functional hand; intermittent pain
			(2) Procaine stellate block	Temporary	
			(3) Manipulation of hand under anesthesia; upper thoracic ganglionectomy	Partial	
6. L. M., male, age 29	Minor laceration of thumb on wire	2 mo.; burning pain in thumb and hand; sweaty, warm and swollen hand; personality changes	(1) Laceration not closed	None	6 yr.; hysterical paralysis postsympathectomy and still unable to move fingers; no pain
			(2) Wound explored; no pus	None	
			(3) 11 stellate ganglion blocks	Temporary	
			(4) Upper thoracic preganglionic sympathectomy	Permanent	
7. E. S., female, age 52	Minor laceration of 5th finger	6 yr.; burning, severe pain in little finger; hyperesthetic to touch and pain	(1) 15 operations "on nerve" reported by patient	None	4 yr.; complete relief
			(2) 3 stellate blocks	Temporary	
			(3) Upper thoracic ganglionectomy	Permanent	
8. J. R., male, age 39	Arm and brachial plexus stretched in auto accident	2 yr.; sharp pain in thumb, constant, burning; atrophy of shoulder muscles, fair grip, weak flexion of elbow; numbness in radial distribution of hand	(1) Arthrodesis of shoulder	None	5 mo.; partial relief
			(2) Transplant of antecubital flexors to humerus	None; improved function	
			(3) Stellate block	Temporary	
			(4) Upper thoracic ganglionectomy	Partial	
9. B. H., male, age 31	Crush injury to hand by punch press	1½ yr.; burning pain in ulnar portion of hand with numbness in 4th and 5th fingers; contractures of these fingers	(1) Tendolysis	None	1 yr.; no pain; cannot make a good fist
			(2) Procaine stellate block	Partial	
			(3) Upper thoracic ganglionectomy	Permanent	
10. J. P., male, age 66	Crushing and tearing of left hand by factory machine	11 yr.; severe burning pain in fingers and hand radiating up to shoulder; wears glove; guards hand; skin shiny, thin, and hand cold; personality changes	(1) Neurolysis of median nerve	None	4 mo.; still has some pain and wants hand amputated, even though it is improved
			(2) Stellate ganglion block	Partial	
			(3) Upper thoracic ganglionectomy	Partial	
11. V. A., female, age 33	Cutting injury to tip of thumb	3 yr.; burning pain radiating from thumb to elbow; sensitive to touch; shiny, sweaty thumb, more painful when cold	(1) Primary suture of laceration	None	No relief for 1 yr. after sympathectomy, then complete relief by amputation; painless, functional hand at 15 mo.
			(2) Stellate ganglion blocks	Partial	
			(3) Excision of neuromas, digital nerves, thumb	None	
			(4) Upper thoracic ganglionectomy	None	
			(5) Amputation of thumb	Complete	
12. N. W., female, age 28	Laceration of popliteal area in auto accident	4 yr.; knife-like, cramping, burning pain from foot to knee, worse walking; plantar ulcer, foot drop and hypesthesia present	(1) Neurolysis of sciatic nerve at popliteal area	None	2 yr.; no relief; question of chordotomy arises
			(2) Lumbar sympathetic block	None	
			(3) Lumbar sympathectomy L 2–3	None	

The average interval was five years. Two of the patients who received relief of pain following sympathectomy developed hysterical paralysis and were unable to use or move their hands postoperatively.

One patient who did not get relief following sympathectomy is a thirty-two year old white woman who received a cutting injury to the left thumb in October, 1952. She complained of severe burning pain in the thumb which was made worse

TABLE II

THIRTEEN PATIENTS WITH CAUSALGIA TREATED WITH LOCAL OPERATIVE PROCEDURES

Case	Character of Injury	Symptoms	Surgical Procedures	Relief	Follow-up after Last Procedure
13. A. P., male, age 42	Index finger lacerated when pole fell on it	Constant aching pain in index finger which shoots up forearm; hypersensitive finger which he guards; tingling present but no numbness; personality changes	(1) Initial wound sutured (2) Resection of digital nerves with neuromas (3) Digital block (4) 3 stellate blocks	None None Temporary Partial	2½ yr.; gradual relief occurred; he is now working; has few paresthesias and no pain; neurosis improved
14. R. C., female, age 46	Crush amputation of index, middle and ring fingers	Sharp, acute, stinging pain in stumps of fingers	(1) Split-thickness skin graft and revision of stumps at time of injury (2) Scarification of palm (3) Stellate ganglion block	Pain began None Complete	1 yr.; working; no pain
15. M. S., female, age 51	Fell downstairs and lacerated ring finger	Constant knife-like pain from dorsum of hand to shoulder; swollen, red hand; cannot make a fist; guards hand	(1) Tendolysis of extensor tendons and excision of painful scar (2) 1 stellate block	Partial	5 yr.; pain present to slight degree
16. M. S., female, age 29	Sewing machine needle broke off in tip of index finger	Painful paresthesias in index finger extending to hand; protects finger; slight loss of light touch in finger	(1) Immediate removal of foreign body (2) Exploration for additional foreign body, 4 mo. later (3) Stellate ganglion blocks	None None	1 yr.; pain persists but patient returned to work
17. L. G., male, age 38	Laceration of thumb on conveyor	Constant burning ache in thumb; personality change; insisted from beginning that thumb be amputated; compensation neurosis(?)	(1) Primary suture of wound (2) Excision of neuroma (3) Tendolysis and neurolysis (4) Stellate ganglion blocks (5) Local procaine infiltrations (6) Amputation of thumb	None None None None None Complete	1 mo. after amputation of thumb he has no pain
18. M. B., female, age 33	Through and through puncture wound of hand by electric welder	Severe pain in hand which radiates to shoulder; semi-clawed 3rd, 4th and 5th fingers; pain worse with movement	(1) Local infiltration of procaine into scar (2) Painful scar excised (3) Stellate ganglion block	None Partial None	4 yr.; no pain; hand slightly swollen; fingers still contracted
19. A. L., female, age 29	Minor crushing blow to back of hand	Constant aching pain shooting from hand to shoulder; worse with emotional stimuli; numbness and tingling in 4th and 5th fingers; cold hand	(1) Immobilization (2) Procaine injections (3) Stellate block (4) Tendolysis at wrist (5) Excision of scar and incision of carpal ligament (6) Neurolysis of ulnar nerve	None None Partial None None	1 yr.; no pain; feels fine
20. W. R., male, age 38	Gunshot wound to left palm and wrist; median nerve partially severed	Burning pain in thumb and index finger radiating into wrist	(1) Neurolysis of median nerve (2) Neurolysis and excision of palmaris longus tendon (3) Stellate ganglion blocks (4) Neurolysis of median nerve and secondary suture of palmaris longus tendon (5) Local injections of procaine and cortisone	None None None Partial Complete	1 mo.; no pain; to have repeated local injections if pain returns
21. C. L., female, age 18	Laceration of hand between thumb and index finger by shears	Throbbing, aching pain of entire hand with numbness and tingling	(1) Neurolysis of digital branch of median nerve and tendolysis of flexor pollicis longus (2) 2 injections of procaine and hydrocortisone into painful area	Partial Partial	4 mo.; slight aching pain still present
22. M. K., female, age 18	Lacerated wrist 15 yr. ago	Aching pain with paresthesias of middle finger; pain radiates from wrist to shoulder with motion	(1) Neurolysis of median nerve (2) Excision of neuroma and secondary suture of median nerve at wrist (3) Local injections of procaine and cortisone	None Partial Partial	3 yr.; pain is mild and intermittent, and controlled by local injections
23. F. K., male, age 59	Drill injury to ring finger with lacerated digital nerve	Electric-like aching pain with tingling, made worse with cold; sweaty hand; wears glove for protection	Excision of scar and secondary suture of digital nerve	Partial	2 yr.; partial relief persists; he is working
24. F. G., male, age 59	Steel plate fell on foot; minor crush	Bitter shooting pain from dorsum of foot down to large toe; large toe is bluish and sensitive to touch	Lumbar paravertebral block with procaine	Complete	6 yr.
25. S. S., male, age 22	Shrapnel wound in calf of leg	Pins and needles sensation in leg with numbness of sole of foot; sole is hypersensitive to touch; weakness and atrophy of calf muscles; neurotic	Popliteal fossa explored; neurolysis	Partial	13 yr.; unable to stand very long without pain; sole feels numb yet is hypersensitive to tactile stimuli; working

TABLE III

SIX PATIENTS WITH CAUSALGIA TREATED WITH STELLATE GANGLION BLOCK AND THREE PATIENTS WITH CAUSALGIA TREATED WITH LOCAL INFILTRATION OF PROCAINE

Case	Character of Injury	Symptoms	Procedure	Relief	Follow-up
26. O. M., female, age 40	Pelvis fracture from automobile accident	Burning and tingling pain in foot, radiating up leg	Lumbar paravertebral block	Complete	7 yr.
27. S. C., male, age 35	Buckshot wound of arm; no sensory deficit	Burning, aching pain; constant pain radiating from forearm to shoulder; intermittent pain in 4th and 5th fingers	2 stellate ganglion blocks	Complete	8 yr.
28. G. J., male, age 47	Automobile fell and pressed arm and shoulder	Stinging, burning pain in hand radiating to shoulder; hand hypersensitive to tactile stimuli; hand slightly swollen	5 stellate ganglion blocks	Complete	6 yr.
29. T. O., male, age 29	Crushed ring finger in machine and distal phalanx was amputated	Constant burning, unbearable pain in ring finger and forearm with feeling of coldness; neurotic	Stellate ganglion blocks	Partial	3 yr.; no pain at present; soaks stump of finger in water as it feels tight intermittently
30. S. C., male, age 40	Shrapnel wound of forearm and compound fracture of radius; tissue lost from forearm	Constant burning, aching pain in hand and forearm; hand is tender to touch and pain is worse when cold; weakness of wrist	(1) Primary repair while in military service (2) Stellate ganglion blocks 2 yr. later	None	13 yr.; pain still present; psychotherapy has not helped
31. C. C., male, age 51	Brachial plexus block for excision of wrist ganglion; hemopneumothorax produced	Constant pain like someone screwing a corkscrew down arm from shoulder to hand; hand sensitive to tactile stimuli	(1) Stellate ganglion blocks postoperatively (2) Stellate ganglion blocks 1 yr. postoperatively	Temporary partial None	1 yr.; still had burning pain with use of arm; spontaneous pain at night; is very nervous and irritable
32. R. E., male, age 47	Faucet laceration of thumb	Constant burning in thumb; shiny, reddened palmar surface; slight atrophy of forearm	Brachial plexus block	None	1 yr.; no pain; improved gradually; still has some numbness of thumb; thumb functions well
33. C. Z., female, age 40	Minor laceration of ring finger on glass	Burning, aching pain which shoots from finger up arm; finger is swollen and bluish; personality change	Local infiltration of procaine	None	2 yr.; no pain; gradual improvement; has developed depression and requires electric shock therapy
34. C. P., male, age 27	Caught thumb in vise; no fracture	Aching, burning pain from thumb up to shoulder; sweaty hand; pain worse on motion	Local infiltration of procaine 8 times into thumb	None	6 yr.; gradual relief

when exposed to cold. The thumb was shiny and perspired profusely. In February, 1955, an exploration was done with excision of neuromas from the digital nerves of the left thumb. Five months later a stellate ganglion block gave her temporary relief. A left dorsal postganglionic sympathectomy was performed with removal of the second and third thoracic ganglia. This did not relieve the pain but did change its character. The pain lost its burning quality and continued as a pricking sensation radiating to the elbow. The patient complained of hyperesthesias about the thumb and a very slight touch caused her to jump. She constantly guarded her thumb. One year following sympathectomy an amputation of the distal third of the first metacarpal was performed along with excision of neuromas. This operation relieved the pain. At the present time the stump is well padded and the patient has a good functional hand. The pain has not recurred fifteen months following amputation.

The second failure from sympathectomy was in a middle-aged white woman who had lacerated the right popliteal area in an automobile accident nine years previously. She complained of pain in the right foot ascending to the knee in the peroneal nerve distribution. There was a chronic plantar ulcer and the foot had undergone trophic changes. Five years after the injury an exploration of the nerves at the popliteal area had been done but did not relieve the pain. The pain was knife-like, cramping and burning, and was made worse on use of the knee. A sympathetic block was done in the lumbar area which did not give relief. A right lumbar sympathectomy was performed under spinal anesthesia but failed to stop the pain. The patient was followed up for two years then lost to follow-up.

When there is no relief from sympathetic block, as in the latter case, there is no indication for sympathectomy. The sympathectomy should include resection of the upper three lumbar ganglia for injuries to the nerves below the knee, and as high as the tenth or eleventh

thoracic if the wounds involve the sciatic trunk in the thigh or buttock, according to the experiences of Mayfield and Devine [8].

A group consisting of thirteen patients was treated primarily by various operative procedures on the wounded extremity. (Table II.)

TABLE IV
EFFECT ON PAIN OF LOCAL NERVE BLOCK*

Result	No. of Cases
Complete relief	1
Partial relief	3
No relief	8

* A procedure used in 12 cases in the treatment of 34 patients with causalgia.

TABLE V
EFFECT ON PAIN OF WOUND EXPLORATIONS*

Result†	No. of Cases
Complete relief	3
Partial relief	6
No relief	13

* A procedure used in 22 cases in the treatment of 34 patients with causalgia.
† Two were relieved by amputation.

Three patients received permanent relief from these operative procedures. Six received partial relief from similar operations. Four were not relieved by surgery on the painful extremity. Eight of these patients also received sympathetic ganglion blocks. In one patient partial relief of pain was produced by the block. In two there was complete relief from stellate block. In five there was no relief. Local injection of procaine into the painful area was done in eight patients of this group. One received complete relief, three partial relief and four had no relief of pain even though the part was anesthetic to examination. None of the patients received local infiltration of procaine distal to the wounded area, which relieves pain in some as reported by Barnes [1].

A third group of nine patients was not treated by sympathectomy or exploratory operation, but by local infiltration of procaine into the painful part or sympathetic block. (Table III.) Three of this group received local block but none received relief of pain. Six received sympathetic ganglion blocks and three received lasting complete relief from this treatment. Two received partial relief, but in one the pain persisted.

The total number of procedures used in the treatment of the thirty-four patients with causalgia is seventy-four. Stellate block or neurolysis is counted only once on each patient receiving such treatment even though the procedure may have been repeated. The relative effect on pain of these procedures is shown in Tables IV to VII. It can be seen that local nerve block was quite ineffective, local operative procedures were helpful in about 40 per cent, sympathetic block was helpful in about 70 per cent and sympathectomy aided the greater number of cases. The importance of early recognition is important because if diagnosed and treated early, skeletal contractures, muscular atrophy from immobilization, osteoporosis and personality changes will be avoided. Not all cases will require sympathectomy. The first logical procedure is chemical blocking of the regional sympathetic ganglia with a local anesthetic agent. This should be done prophylactically in any injury which produces a burning type pain or in which the vascular supply to an extremity is impaired

TABLE VI
EFFECT ON PAIN OF SYMPATHETIC GANGLION BLOCK*

Result	No. of Cases
Complete relief	5
Partial relief	13
No relief	8

* A procedure used in 26 cases in the treatment of 34 patients with causalgia.

TABLE VII
EFFECT ON PAIN OF SYMPATHECTOMY*

Result	No. of Cases
Complete relief	6
Partial relief	4
No relief	2

* A procedure used in 12 cases in the treatment of 34 patients with causalgia.

or threatened. Certainly sympathetic block should be done where pain persists beyond the usual period of healing. Relief of causalgic pain generally coincides with ganglionic block and may last for many hours. When relief persists for a longer time, it is advisable to try a series of blocks in the hope that the early mild cases of causalgia will improve progressively. This occurred, with the result that no sympathectomy was necessary, in forty of 344 cases reported by Mayfield [7], in two of sixty-four cases of major causalgia reported by White and Selverstone [16], and in five of this presented series of thirty-four. When relief is definite but brief, it is best to proceed with sympathectomy. When two diagnostic sympathetic blocks are done without relief, sympathectomy is not indicated.

Local operative procedures are helpful but are not expected to help major causalgias. According to White, Smithwick and Simeone [15], it is inadvisable to resect a neuroma in continuity in the early stages for pain unless the scarring is so severe that the nerve fibers are entirely interrupted. Reinnervation and recovery of function may never be as complete as if the nerve were left alone or a simple neurolysis were performed. Such local procedures may be more effective following sympathectomy if then required at all.

SUMMARY

Thirty-four patients with minor causalgia as seen in civilian life are reviewed. They were predominently men in the fourth and fifth decades. The type of injury varied from minor blows to severe crush injuries. The pain was unusually burning and constant and was associated with vasomotor dysfunction. The patients were treated by various means. Sympathectomy gave relief in most cases, followed by sympathetic ganglion block, local operative procedures and local nerve block in that order of effectiveness.

CONCLUSIONS

1. Major causalgia is rarely, if ever, seen in civilian life.

2. Local operative procedures are of little value in relieving causalgic pain.

3. Sympathetic ganglion block should be used early in the treatment of minor causalgia, and in a significant number of cases relief will be obtained from repeated blocks.

4. Sympathectomy is the best treatment for causalgia if the pain is temporarily relieved by sympathetic ganglion block.

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DISCUSSION OF PAPERS BY DRS. CRANLEY AND KRAUSE; HARMON; AND HARDY, POSCH, WEBSTER AND GURDJIAN

Lester Breidenbach (New York, N. Y.): This is a very interesting subject in that injuries about the shoulder and the upper arm do involve the arterial system frequently, and the main contribution to the subject is the diagnosis. There are innumerable dislocated shoulders which involve the axillary artery and very often the artery is contused, with a severe spasm and resulting absence of pulse in the wrist. A moot question is posed at this time whether such a patient ought to be oper-

ated upon or treated conservatively, usually with sympathetic nerve blocking, in order to relieve the spasm.

I think the main feature of Dr. Cranley and Krause's paper is the fact that a great many of these blood vessels should be explored because it is almost impossible at times to make an accurate diagnosis. Early exploration will, of course, reveal the pathologic condition.

Very often it is a severance or partial severance of the blood vessels which necessitates re-establishing the continuity. It is difficult to tell whether the artery is contused or lacerated. It does happen that in some severe contusions there is early thrombosis at the site of the contusion. This, too, requires surgical exploration or surgical correction in order to re-establish the continuity of the vessel. The continuity certainly should be re-established in every instance, where possible, because with the marked collateral circulation about the shoulder we do get, not gangrene, but some impairment of the function of the arm or leg unless the continuity of the main vessels is re-established.

HARRISON LLOYD MCLAUGHLIN (New York, N. Y.): I am surprised that Drs. Cranley and Krause have encountered two such rare injuries to the brachial artery complicating dislocation of the shoulder. In a large number of dislocations treated on our Service injury to the brachial artery requiring repair has not occurred except as a result of a penetrating wound. I question the advisability of reducing a dislocated shoulder with jeopardized circulation in the extremity by the Hippocratic method. The heel of an inexperienced surgeon in the axilla of a dislocated shoulder may well produce an injury to the great vessels or nerves.

Dr. Harmon is to be congratulated that nowhere in his essay did he use the word "bursitis." Many painful shoulders are treated inadequately or are overtreated. One of the main reasons for this deplorable situation is the widespread use of the loose and all inclusive term "bursitis," which means little more than lumbago and which predisposes to placing all painful shoulders into a single category. He has emphasized that the acutely painful calcium deposit is analogous to a chemical furuncle which usually undergoes spontaneous recovery despite the type, presence or absence of treatment, and that the chronic inflamed deposit can be palliated but otherwise must be tolerated or removed.

I question his contention that a frozen shoulder should not be manipulated in the *active* stage. It has been my impression that cessation of activity coincided with commencement of spontaneous recovery and relief of pain. My experience has been that manipulation, in any stage, often accomplished more harm than good.

Some years ago I had the opportunity to open a group of stiff shoulders prior to manipulation. This was done in an attempt to localize and identify the "adhesions" which manipulation was then thought to disrupt. It was found that manipulation disrupted the anatomical components of the shoulder rather than adhesions. The consequent tissue damage was astonishing and beyond control of the manipulator. For this reason, when mobilization of a shoulder is necessary, we now elect to do the procedure by an open operation wherein only the tight structures are divided.

JOHN ELLIOTT WEBSTER (Detroit, Mich.): I would like to make one point regarding Dr. Hardy's presentation which concerns the treatment of the minor causalgias, because the major causalgias, as was pointed out, are not actually a problem which we encounter frequently. But we must give our attention to the site of injury in this minor group.

May I show one slide to illustrate this point briefly? Here is a major nerve which is adhering to the surrounding tissue, as occasionally occurs in lacerated wounds and particularly in war wounds. In dealing with this autonomic effect due to pull on the nerve through the adherent muscle, it is quite important to relieve this as early as possible.

This fact seems to be of cardinal importance; and if these lesions can be treated early, the autonomic effects then become much less serious. The approach to the secondary effects involving the sympathetics must, of course, be attacked by the stellate blocks and then sympathectomy if indicated.

Our terminology is often misleading in dealing with these cases, and we must be quite specific, I think, in identifying the exact type of causalgia which is meant when we are also talking about treatment.

ROBERT D. LARSEN (Detroit, Mich.): I have certainly enjoyed the paper presented by Dr. Hardy and his associates. The authors have brought up a problem which gives a great deal of trouble to anyone engaged in the care of injured extremities. The painful post-traumatic states in the upper extremity are quite common. Most of these conditions fall into the group of amputation neuromas, painful traumatic arthritis, paresthesias, irritation of nerves from tight scars, etc. Between this latter group and true major causalgia there is an intermediate group of painful states which the authors and others have designated as minor causalgia. As indicated in Dr. Hardy's paper, it is doubtful that we ever see a true or major causalgia in civilian practice. We certainly see post-traumatic states characterized by burning pain, atrophy of the skin, hyperhidrosis and hyperesthesia. These conditions are seldom relieved by local procedures, as is encountered, for example, in the resection of simple amputation neuromas. I believe it is fair to call these states minor causalgia and to treat them as such.

It is important to distinguish minor causalgia from Sudeck's syndrome. Although sympathec-

tomy is said to relieve Sudeck's syndrome, in most cases immobilization will suffice. Immobilization is apparently not as efficacious in causalgia.

The fact that not all cases of minor causalgia are relieved by sympathectomy should not discourage one from offering the operation to a patient with this syndrome. The tendency for sympathetic fibers to regenerate, the presence of intermediate or aberrant ganglia in many persons, and the fact that the upper extremity may receive sympathetic innervation from the first to the ninth thoracic segments in a few individuals, would seem to make complete sympathetic denervation most difficult. In spite of these anatomical difficulties the authors have benefited a significant number of their patients.

As Dr. Hardy has indicated, four of his patients came from a group of 204 patients with peripheral nerve injuries in the upper extremity whom I have been studying. Others have also reported that causalgia will develop in about 2 to 3 per cent of peripheral nerve injuries. The impression that causalgia is more apt to occur in torn, crushed or partially lacerated nerves than in cleanly incised nerves would appear to be valid.

Chlorpromazine has been reported to relieve the pain of causalgia. I would like to ask the authors if they have had any experience with the use of chlorpromazine in causalgia. I would like to offer the observation that these causalgia-like states are not seen in the city hospital clinics, while they are fairly common in industrial compensation cases, and ask the authors to comment on this impression.

Again, I would like to compliment the authors on a very interesting and timely presentation.

RALPH G. CAROTHERS (Cincinnati, Ohio): I was on this platform at our very first meeting, I guess it will be twenty years ago next spring.

Dr. Cranley's experience is a little greater than mine in the cases of axillary disturbance. I have had exactly one case, and that occurred in a nurse on duty in the hospital. She was having such terrific pain when I arrived that I gave her an anesthetic, which is not my usual custom in dislocated shoulders. The shoulder was reduced by what I call the Kocker method, although I think it is a little different from the pictures in the book. We did not have any more trouble.

This putting the foot in the armpit is a horrible thing, and I do not know what we are going to do to teach these boys any better, because they are never around when there is such a case.

GRAHAM A. KERNWEIN (Rockford, Ill.): I wish to comment on Dr. Harmon's paper. First he did not tell his criteria for making a diagnosis of frozen shoulder; second, if he told his method of treatment of this condition, I did not hear it.

Frozen shoulder involves glenohumeral fixation, the result of capsulitis, the cause of which is unknown. Pathologically it is an inflammatory process that results in marked thickening of the capsule with resultant loss of elasticity and reduced volume joint capacity. Manipulation of such a shoulder increases the range of motion only at the expense of rupturing of the capsule and subcapularis muscle. I agree with Dr. McLaughlin that severance of the structures under direct vision is preferable. The prognosis of "frozen shoulder" differs greatly from that of restricted glenohumeral motion due to pain and muscle spasm. They can be differentiated one from the other only when the pain is relieved. This should be done with a local anesthetic in all cases of glenohumeral fixation. I should like to know if Dr. Harmon makes this differentiation.

Arthrography might well improve Dr. Harmon's results in those cases he classifies as tendinitis without calcification and in which only 80 per cent of a 200 case sample group obtained relief. Also, he states that this is not the whole story of this group, for the number of patients lost suggests even less satisfactory results. It is in this latter group that ruptures of the rotator cuff mechanism occur and cannot be identified clinically other than by exploration or arthography. I recommend that he give arthrography a trial.

JOHN J. CRANLEY (closing): I would like to thank Dr. Breidenbach, Dr. McLaughlin, and Dr. Carothers for their comments.

First, the incidence of injury to the axillary artery, in our experience, cannot be considered representative of the true incidence because we are asked to see such patients only after the arterial injury is discovered. Second, we too are surprised at the paucity of reports on this subject. It can only be surmised that some cases either were not reported or that the correct diagnosis was not made.

In regard to the method of shoulder reduction, both these dislocations were reduced by the resident surgeon. In each instance the attending man questioned the wisdom of using this method, but it should be noted that each resident surgeon reported that the pulse was absent prior to the shoulder reduction. In our opinion, the value of these case reports is not in the sphere of shoulder reduction as much as in the management of the arterial injury. We believe that there is sufficient evidence, particularly in the work of Simeone and Kinmonth, to demonstrate that the spasm of a contused major artery cannot be released by blocking the autonomic ganglia. The spasm may be relieved when the source of irritation is eliminated, but not by autonomic nervous system paralysis. We consider it a guiding principle that the absence of a peripheral pulse distally following trauma proximally is an indication for exploration of the artery at the site of injury.

PAUL H. HARMON (closing): Obviously, considerable time can be spent on discussions as to what to do for the painful shoulder. One cannot in twelve minutes give an adequate description of all the

various therapeutic measures that have been applied over the past twenty years to a group of shoulders such as this.

We believe one of our jobs when the patient comes in with a painful shoulder is to have him understand that the term "bursitis" is entirely analogous to the term "peritonitis." It is a symptomatic diagnosis; and if bursitis is present at all, it conveys no therapeutic implications.

In regard to Dr. McLaughlin's comments on what to do with calcific tendon deposits causing acute symptoms, we have some accurate statistics on this point which show that the "acute deposit" treated by hospitalization, traction, rest, heat and other non-direct methods requires four to five times the period of recovery than does a favorable response to surgery. I want to quote one particular case of a friend who called me up four years ago at 3:00 A.M. describing a typical acute onset of pain in the shoulder. When sound asleep in bed he had been suddenly awakened by such an acute pain that he thought someone had crept into the bedroom and stabbed him in the shoulder. This dramatic acute onset is due to sudden swelling and rupture of the calcium deposit into the bursa. This man met me at the hospital at 7:30 A.M., we performed an operation under local anesthesia and he was at work at 9:30 A.M. When I saw him two days later, he had a normal range of motion in the shoulder. This merely illustrates that a good many of these shoulder explorations for calcified deposits can be done as outpatient procedures. Ten per cent of patients demonstrating acute shoulder symptoms require operations for acute deposits.

Dr. McLaughlin asked what compound F and cortone® can do. We do not have a controlled study of these patients.

Manipulation of the stiffened "frozen shoulder" should be carried out gently. We do this by grasping the upper arm between one or two fingers and the thumb. One should not attempt, if any resistance is experienced, to get anywhere near the full range of motion. I do not believe that anyone should be manipulating shoulders who uses force and attempts to put every shoulder through a full passive range when the patient is insensible under an anesthetic.

When should we manipulate the frozen painful shoulder? Certainly when the patient is "fed up" with the situation and comes to you with a history of a year or so of various kinds of "shots" and office treatment of diathermy, ultrasound and other forms of radiant energy, it is time to carry out some definitive type of treatment. The simplest approach and one most likely to yield increased motion and ultimately relief from pain is a carefully conducted manipulation under anesthesia followed by exercises.

Acromion resection is a final measure for the frozen shoulder, to be applied after either all else has failed or certainly after the patient has been in a stationary phase for several months. We have been pleased and gratified at the response in steadily increasing motion and finally return to normal or near-normal range in patients given up as "hopeless" after months and even years of treatment of the conservative type, who have submitted to acromion resection and promptly regained motion. The removal of this osseous block was evidently the measure that "tilted the scales" favorably enough to allow the patient to exercise and regain motion.

W. G. HARDY (closing): In answer to Dr. Larsen's question about the use of chlorpromazine I can say, "No, we have not used it with that specifically in mind." A few cases have been reported in the literature, which improved after the use of chlorpromazine, but it is not stated definitely what type of causalgias these patients had. I think a lot more work would have to be done with this drug before we can say it is a treatment for causalgia.

A number of our patients had been given tranquilizers because of their marked emotional changes. These never seem to stop the severe pain in true causalgia.

Dr. Harmon also asked why he never saw these cases in city hospitals. I think it has to do with the great emotional factor that is present in some of these patients, especially the factor of compensation. The patients you see in the city hospital may have Blue Cross or other forms of hospitalization, but most injuries occurred after a good fight on Saturday night and did not occur in a factory. That is not an injury for which they may later seek recompense. Many of these people who have true causalgic syndrome will withdraw from surroundings. They like to be in a quiet, dark room. They wear a glove or keep a wet protective covering on the hand. They will not allow you to touch it or come near it. In some cases these people become dope addicts or alcoholics. In this type of patient you have to be very careful to make sure he is not a malingerer or that he has a neurosis not caused by the causalgia. The best way to get around that is to call in a psychiatrist to help you.

Two of our patients had hysterical paralysis following sympathectomy even though the pain was relieved. These patients were not seen by a psychiatrist, however, until after sympathectomy. He thought they both had fixation neuroses.

Another thing to do is a stellate block. If the patient gets relief longer than you think he should, and if the relief persists until after the anesthesia has worn off, you have to repeat the block, because repeated blocks may cure the patient. On the other hand, during a series of blocks, you should do one with normal saline or some such solution that will not anesthetize the patient. If he gets relief from that type of injection, sympathectomy is not indicated.

Fractures of the Os Calcis

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FROM the extensive literature on fractures of the os calcis several basic approaches to the treatment of these fractures have been developed. Each method has been modified in many ways. All authors agree that in general the results of treatment have been poor. In most cases this is attributed to a failure of, or lack of, adequate treatment, and many minor variations in technic are presented as the assured key to a good prognosis. Too little attention has been given to the etiological factors underlying the symptoms which result in permanent disability. Conflicting statements indicate a lack of knowledge of the natural history of the injury. It was therefore considered worthwhile to study a series of cases treated in several different ways to evaluate the long-term results of the injury and to study the causes of residual disability.

The treatment of fractures of the os calcis appears to have consisted of little more than bandaging and elevation from the time of Hippocrates until 1850. At that time, in an attempt to improve on this treatment a traction device was used by Clark [1]. Charles Bell [2] of Edinburgh reported an open reduction in 1882. These methods were designed to reduce the fragments of the os calcis to their normal position and modifications of these two basic approaches have been numerous. Goff [3] in his excellent review of the literature records 156 articles from 1720 to 1936. Many more have appeared since then. Another approach was used by Cotton and Wilson in 1908 [4] who described a method to produce disimpaction of the fracture fragments by hammering followed by manual moulding to achieve reduction. Apart from these four fundamental approaches to therapy there has been little change in the form of treatment over the years. Böhler [5,6] refined Cotton's method by using traction with pin fixation. His name has been applied to the tuber-joint angle whose correction he emphasized.

Residual pain has been attributed by nearly all authors to a damaged subastragaloid joint and this joint has been fused alone or in conjunction with other tarsal joints, both immediately after injury and as a late procedure [7,8]. No one has seriously challenged the concept of subastragaloid fusion being a benefit in cases with damage to the subastragaloid joint. The proponents have claimed to be able to forsee the result of non-operative therapy so well that they do not feel it necessary to wait for symptoms to appear before going ahead with a subastragaloid fusion.

The study of roentgenograms and specimens has led to numerous classifications of the types of fractures with a better understanding of the forces producing the fractures. This has resulted in the recent popularity of reduction with a Gissane spike inserted into the tuberosity as described by Essex-Lopresti and of open reduction with bone grafting. Lenormant and Wilmoth [9], Murray [10] and Palmer [11] have described a method for inserting bone grafts to maintain the correction after open reduction of a depressed articular surface in the subastragaloid joint.

MATERIAL STUDIED

Source of Material. Three hundred ninety case histories were obtained from the records of the Toronto General Hospital and from the Workmen's Compensation Board of Ontario. In the great majority injury had occurred ten to eleven years previously. Eighteen of these cases had insufficient information to determine the type of injury to the os calcis. Of the remaining 372 cases eighty-six or 30 per cent of the fractures did not involve the subastragaloid joint.

It is well known that most poor results in

os calcis fractures occur in the group of "crush" fractures involving the subastragaloid joint. An attempt was made to follow up as many of these patients as could be located still living in Ontario. Of the total of 286 case histories it was necessary to discard sixteen because of other injuries to the same leg which would make evaluation inaccurate; twenty-two patients could not be personally examined as they were over 600 miles away; eighty-eight could not be located because of moving from their last address; and thirteen were traced and found to be deceased since their injury. It was possible to locate and follow up 147 patients. These were long-term follow-ups with 74 per cent of cases being six or more years after the time of injury. Average length of the follow-up was eight years. We cannot agree with Carothers and Lyons who say of their follow-up, "We think that none of our patients are having trouble because we believe that if they were they would be back complaining . . . " [*12*]. The author found that many patients would not reply to letters of enquiry, or attend appointments, either for economic reasons, for dissatisfaction with their result, or because they couldn't be bothered. Early in the survey it became very obvious that no assumption could be made about any patient and it was necessary to make personal visits to their homes after working hours, often after great difficulty in locating them. Although outpatient clinic, Compensation Board and office records were kindly made available it was found that in general they were insufficiently well documented for our purposes. It finally became necessary to undertake a trip of over 5,000 miles throughout Ontario to personally examine the patients and all but three of the 147 patients were examined by the author. It is believed that these patients represent a fair sampling of the over-all results of the treatment of os calcis fractures in Ontario.

Examination of Material. Care was taken to emphasize to the patient that this was an examination purely for research purposes and would not be available to the Compensation Board or other parties. It seemed that in almost all cases the patient appreciated the examiner's interest and, in the main, honest statements were received with no attempt to exaggerate or manufacture symptoms.

Method of history taking: A history was taken from each patient regarding symptoms present and their relation to daily activities. The patient was questioned regarding pain at night, pain on arising in the morning, and its presence later in the day after activity. He was asked about pain after getting off his feet and whether or not symptoms reappeared when he again walked on his feet. If pain was present its severity and location was determined. Information was elicited as to whether standing, lifting, climbing, or walking aggravated the pain and whether or not it was related to weather. The necessity for soaking the feet and a history of recurrent falling caused by pain gave an indication as to severity. Ability to walk a mile was determined as well as whether or not any recreational activity had been reduced since the injury. A record was made of the work performed before injury and since injury and effects of unemployment were assessed.

Method of examination: Both feet were then carefully examined and compared in relation to areas of tenderness, amount of movement in each joint, and the presence of edema. The presence of peripheral pulses, varicose veins, calluses, hallux rigidus, persistent limp, peroneal spasm, clawing of the toes, heel thickening and weakness of plantar flexion was recorded. The ability to walk on the toes was noted. Finally the foot, heel and calf were measured. This information was then correlated with data from office files and hospital records to give a composite picture of the result of injury both from the opinions of various other examiners over the years, the present examiner and the patient's opinions.

X-rays and their interpretation: (1) X-rays available: Films were taken of each patient to show both the normal and injured foot. These included views of the os calcis and of the ankle joint and of the forefoot. The original films were located in 61 per cent of the cases.

(2) Classification of fractures: The mechanism of fractures of the os calcis has been worked out over the past century and is now fairly clearly understood. Nadal [*13*] and Malgaigne [*14*] in 1843 gave the first classic description and discussion of the mechanics involved. Goff [*15*] has worked out in detail the lines of force and shows the relationship between the upward pull of the tendo achillis and the upward force applied to the heel and forefoot by the ground. This is countered by the downward weight of the body distributed

through the astragalus into the os calcis. Warrick and Bremner have analysed 300 fractures of the os calcis as to type of fracture [*16*]. In the group of compression-shearing fractures they describe the primary fracture line which divides the bone into two fragments and runs forward and laterally from a point on the medial side at a variable distance behind the systentaculum tali. This line may run in front of, behind, or through the posterior articular facet. A secondary compression fracture of the main lateral fragment may occur.

The secondary compression fracture of the posterolateral fragment may include only the lateral part of the posterior articular facet or may result in depression of the entire articular facet. Palmer [*11*] and Essex-Lopresti [*17*] have described this type in detail and note that the articular surface may be intact and compressed downward into the cancellous bone of the os calcis. There are two means by which this may occur. In the first or tongue type the compressed portion of articular surface is continuous with the split upper half of the tuberosity forming a long lever or tongue. This fragment may be rotated with the posterior or tuber end displaced upwards. Essex-Lopresti reduced this with a Gissane spike thereby correcting the displacement of the articular surface.

In the second type of injury termed the "joint depression" type, all or part of the posterior articular facet is separated as a free fragment and compressed downwards into the underlying cancellous bone. Palmer performs an open reduction with elevation of this fragment and insertion of a bone graft in the space beneath it to maintain reduction.

(3) Interpretation of x-rays: In spite of the distinct and well described classifications the authors found it was not possible to classify the x-rays in this series in a detailed manner, nor did there seem to be much value in doing so once damage to the subastragaloid joint was demonstrated. One must constantly keep in mind that the os calcis has multiple facets and often all detail is not visible in the usual x-rays. The authors agree with Wilson [*18*] who wrote that "in view of the great number of fragments present in a severe compression fracture, any operative attempt to replace these fragments must at best be very incomplete."

It was decided to use a classification based on the degree of deformity of the os calcis and the fractures were divided into the following groups: (a) moderate degree of deformity, (b) severe degree of deformity, (c) fractures involving the subastragaloid joint without displacement. (Fig. 1.)

Generally speaking, if Böhler's angle was not reduced to zero degrees the fracture was called moderate.

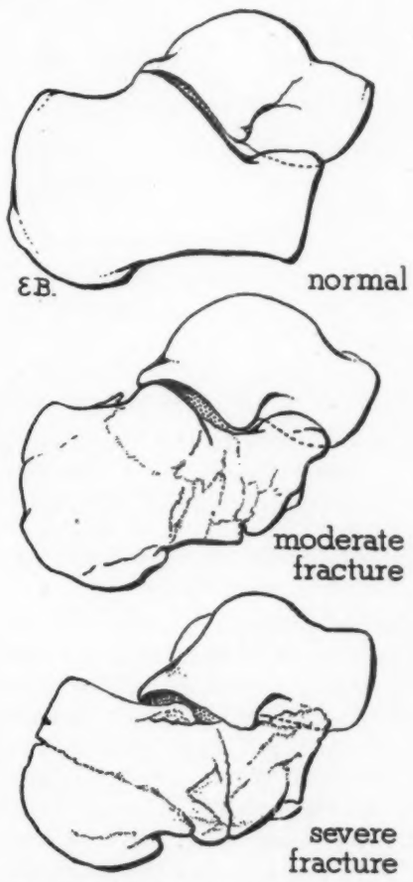
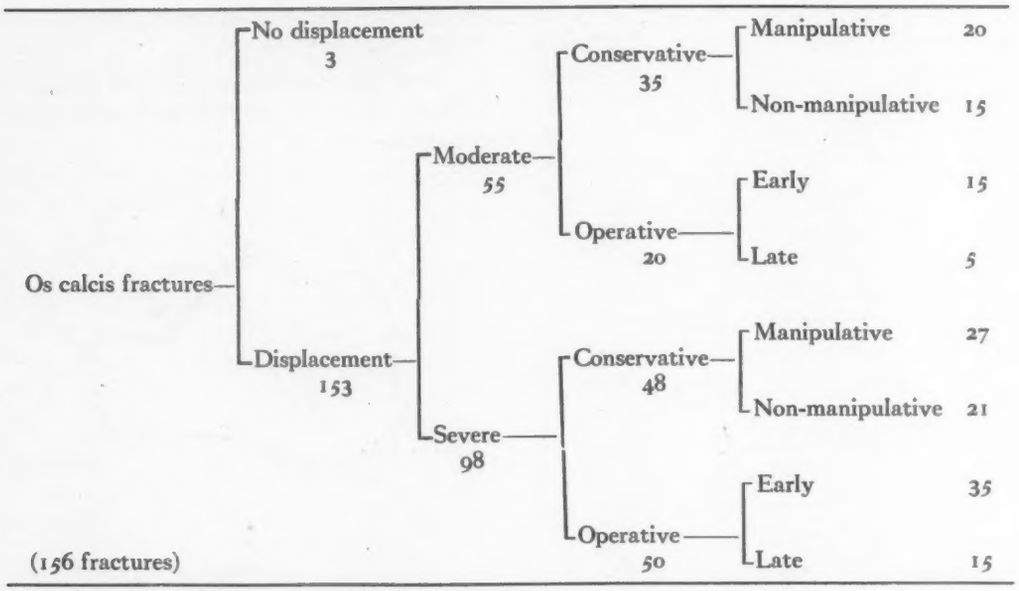


FIG. 1. Classification of fractures based on the amount of deformity in the os calcis.

Methods of treatment: This series of patients was treated in several different ways. The author has designated conservative treatment to include all those treated by methods which do not involve an open operation. In the nonmanipulative group treatment included tensor bandage alone or plaster case immobilization. The fractures of those patients having manipulation were compressed with a Böhler clamp, pounded with a mallet, or reduced by traction with one or more pins.

The operative group underwent a subastragaloid arthrodesis. Early operation refers to those fused within twelve months of injury while

TABLE I
OUTLINE OF CASES



late operation refers to the group fused after failure of conservative therapy. The number of cases in each group are noted in Table I.

NATURAL HISTORY OF FRACTURES OF THE OS CALCIS

Etiology of Fracture. An outstanding feature of the study was a realization of the method in which the injury occurs. In all but thirteen of the cases the fracture was due to a fall from a height. The average height fallen was 17.3 feet with 73 per cent of the patients falling 10 or more feet. Of the remaining thirteen cases seven resulted from being struck by a heavy object and six were due to other miscellaneous accidents. Not enough emphasis has been placed on the type of surface necessary to produce a fracture of the os calcis. Of those landing on a surface, 43 per cent landed on cement or stone, 22 per cent landed on hard ground or cinder surface, 9 per cent landed on frozen ground or ice, and 23 per cent fell onto a wood or steel surface. There was no record of anyone falling onto a grassy lawn or soft ground and sustaining a fracture of the os calcis with involvement of the subastragaloid joint.

It became obvious that it requires a tremendous force to break the os calcis, in fact, when a 170-pound man lands on one heel after falling from a height of 17.3 feet a total of 5,717 foot pounds per second of momentum is developed. This force, when applied to the foot, must spread its effect far beyond the os calcis and the subastragaloid joint, in fact well into the surrounding tissues.

Incidence. One hundred forty-seven patients were examined at an average of eight years after injury. Sixty-three had fractures of the left os calcis and sixty-six had fractures on the right side. There were eighteen bilateral cases making one hundred and sixty-five separate fractures for analysis. Three of these fractures were compound and six others were treated with open reduction. These cases will not be included in the discussion of end results. This leaves a total of 156 separate fractures for consideration, all with fracture into the subastragaloid joint, and three without displacement of the fragments. (Table I.)

Age: The average age at injury was 44.6 years. Seventy-two per cent were between the ages of thirty and sixty. Few people sustain a fracture of the os calcis under the ages of thirty. Many people between the age of twenty and thirty work at heights and it is not clear why they do not sustain fractures.

The results of each type of treatment are not found to be better in any particular age group. Our findings do not agree with those of Essex-Lopresti who concluded that fractures of the os calcis in patients over the age of fifty gave better results with conservative treatment while those in the age group under fifty years were treated better by operative means [17].

Sex: Of the one hundred and forty-seven patients examined, one hundred and thirty-nine were men and eight were women. The incidence is low in women, not because they have any inherent ability to sustain injuries without fracturing the os calcis, but because they are not employed in jobs requiring them to work at a height. Perusal of the end results shows no particular difference in the two sexes.

Other Injuries. It must be noted that many cases were excluded from this series because of the accompanying injuries to tibia or ankle or other leg bones. It was believed that in these cases symptoms could not be evaluated on the basis of the os calcis fracture alone. Twenty-nine of the patients examined had sustained other injuries and these included fractures of the arms, pelvis and skull, as well as chest injuries. Ten of the one hundred and forty-seven patients had sustained fractured vertebrae making an incidence of 6.8 per cent. More than one vertebra was involved in several cases. Schofield [*19*] reports 12 per cent incidence of vertebral fractures in a series from a younger age group.

Acute Stage of Injury. The tremendous oedema and marked ecchymosis of the foot which accompanies a fracture of the os calcis is well known. This gradually subsides over many days and is certainly indicative of soft tissue injury. Day [*20*] attributes some of the persistent pain to scarring in the torn tissues. In this series the usual treatment for the first few days has been elevation and compresses. Some patients received lumbar sympathetic blocks with no marked change in their course.

Whatever the early treatment the patients treated conservatively show gradual subsidence of the oedema and tend to have a relatively painless foot until weight bearing begins. Commencement of weight bearing varies with the surgeon and with the ability of the patient to put weight on the foot. The pain experienced on weight bearing is of several types and will be discussed later. In almost all cases there is a gradual improvement in the degree of pain until they are left with no pain or with certain definite areas of pain.

Intermediate Stage of Injury. This improvement tends to stop after a few months and the pain remains constant. The period of time for symptoms to stabilize and have little further improvement is shown in Table II. Fifty-seven per cent of patients stabilized in one year or less, while fifteen per cent took three years or longer. No one has adequately explained why a pain should be continually present in an area for years without showing change. The authors were impressed that some of those who returned early to heavy labour and remained at this work in spite of severe pain tended to do very well and had little or no symptoms. This may be related to the personality of the patient or to early activity improving soft tissue adjustments. Heavy boots were helpful in some cases.

TABLE II
TIME FOR SYMPTOMS TO STABILIZE

Treatment	Months to Stabilize
Non-manipulative conservative	16.6
Manipulation or traction	17.2
Surgical arthrodesis	19.5

Late Stage of Injury. Continued improvement: On examination at ten-year follow-up some patients claimed that they were still experiencing slow improvement in their foot and cited activities they could do which they could not tolerate two years previously. This slow improvement was stressed by Olovson [*21*] and Mercer [*22*].

Essex-Lopresti did not find one patient whose symptoms had become worse in up to eight years' follow-up. In this series nine patients of the totals of 147 stated that their symptoms had become worse in recent years. The time from injury to increase of symptoms averaged 8.8 years with all over four years. The symptoms appeared to implicate the ankle in four cases, the subastragaloid joint in three cases and the heel in one case. Arteriosclerosis with claudication was the cause in the ninth case.

Attention should be drawn to the fact that patients may have a flare-up of rather severe pain lasting from a few days to three or four months with final return to their former state. This occurred in seven cases in this series at an average of 4.7 years after injury. In some it involved the heel or ankle, and in others the entire foot, or even the leg. One man described it as so severe he could hardly stand it. Three had accompanying marked oedema. In three cases, one with oedema, a tensor bandage seemed to relieve the pain. No history of

thrombophlebitis could be obtained in relation to these episodes. The important feature is that the pain and oedema do subside and are not an indication for subastragaloid arthrodesis as was recommended to more than one of these patients.

TABLE III
SIGNS AND SYMPTOMS RELATED TO TREATMENT

Type of Treatment	Affected by Weather (%)	Tiredness in Foot (%)	Ability to Toe Walk (%)	Limp (%)	Oedema (%)
Non-manipulative conservative.....	39	25	58	22	17
Manipulation or traction.....	40	17	70	28	26
Surgical arthrodesis	41	14	54	50	37

Weight bearing: There is little difference in the time at which full weight bearing was begun in each type of treatment. The patients who were treated with tensor bandage or plaster immobilization appeared to be ambulant a little sooner than the other types.

Toe walking: This has often been used as a rough test of the result obtained in fractures of the os calcis. Table III shows that over half of the patients were able to toe walk well with a higher per cent in the reduced group. Watson-Jones [23] attibutes inability to toe walk to relative lengthening of the tendo achillis resulting from upward displacement of the calcaneal tuberosity. This feature was carefully looked for in all cases and in only two patients could weakness of plantar flexion be demonstrated in a test using manual resistance to plantar flexion of the foot. Toe walking was prevented by pain in the ankle region, pain elsewhere in the foot or by stiffness of the ankle or foot. Seventy to 90 per cent of the good results could toe walk. This indicated that toe walking is a relatively good test of the clinical result.

Limp: The incidence of limping appears to increase with manipulation or operation on the foot. This seems to be related to rigidity in the foot. A limp was present in 22 per cent of conservatively treated patients and 50 per cent of the surgically arthrodesed group. One-half to two-thirds of these patients had a constant limp while the remainder had some limp at the end of the day.

Calf atrophy: The majority of patients continued to have one-half to three-quarters of an inch of atrophy in the calf muscles at eight year follow-up. In a few the muscle had returned to its normal bulk. The atrophied muscles were not weakened in most cases when compared to the opposite side. There was no obvious reason why in some instances the muscle had returned to its normal bulk.

TABLE IV
TIME ABSENT FROM WORK

Treatment	Time Absent from Work (mo.)
Non-manipulative	5.5
Manipulation or traction.....	6.8
Surgical arthrodesis.....	10.0

Weather: Forty per cent of patients, no matter how treated, complained that their symptoms were aggravated by changes in the weather, particularly before the onset of damp weather. In some cases this was a serious complaint.

Oedema: The daily appearance of oedema was usually associated with pain and did not have any demonstrable antecedent of phlebitis. Oedema was common in the series and appeared in over 20 per cent of the patients. Table III presents the distribution and there is an increased incidence where the foot has been interfered with. It is significant that only 13 per cent of the good results had oedema while 54 per cent of the poor results complained of oedema.

Ability to return to work: There has been a great deal of discussion in the literature about the degree of permanent disability. McFarland [24] discusses the figures for disability as reported in several series and shows the disability to range from five months to two years with little relation to the type of treatment involved. Permanent disability of the foot is reported as from 30 to 75 per cent [25]. This is difficult to evaluate and varies with the examiner.

In Ontario during the period of treatment, compensation payments cover two-thirds to three-quarters of the salary. Claims are adjusted by a board of doctors and there is little advantage in remaining away from work unnecessarily. Table IV shows the average time off work for each group. The poor results were back to work as soon as the good results in the

conservative group. Operative treatment delayed the return to work by four months.

In this series of 147 patients there were only four who never returned to a formal job again. They were forty, sixty-eight, sixty-nine and seventy years of age at the time of injury. Three of these had surgical arthrodesis, one requiring refusion. Inability to return to work was partly due to arthritis of the hip in one case and disability of the back in another.

In eighty-two conservatively treated patients, seventy were at heavy work before injury. Fifty-five or 79 per cent remained at heavy work after conservative treatment. Twelve further cases were on light jobs both before and after injury.

In seventy patients, treated by surgical arthrodesis sixty-three were on heavy labour before injury. Thirty-one or 49 per cent returned to heavy labour following fusion. Seven other patients treated by fusion were on light work both before and after injury.

Of the 147 patients, four were found to be using a cane all or part of the time. These four had been treated by surgical arthrodesis.

It has been customary in other reports to attempt to evaluate the total cost of treatment for os calcis fractures. Such assessments cannot be compared from one area to another, as in Ontario the compensation total is related to the individual's job, and his salary, which will vary with the economic status of the area in which he lives. For general interest only we report on the total compensation paid out. This does not include hospitalization costs, rehabilitation center costs, or surgeon's charges. The average was $1,007 in patients treated by conservative measures and $2,400 in patients with arthrodesis. Geckeler [*26*] reports $1,561 as the average amount of compensation paid in fifty consecutive cases. Fifteen of thirty-eight conservative patients are on a permanent pension while twenty-one out of twenty-four patients with arthrodesis are on pension. This excludes costs involved in treatment of other injuries or pensions for these injuries.

END RESULT STUDY

Two approaches were made to the study of the long-term end results. Disregarding the symptoms present the function of the foot was assessed in relation to activities that could be performed. Secondly the symptoms still present in the foot were studied.

End Result Study with Regard to Function. Method of assessment: Disregarding the symptoms present and the physical findings in the foot the patients were asked what they could do. In order to compare results it was necessary to have some working basis for determining a good or poor result. The evaluation was made on the following three factors.

(a) The ability to perform heavy work is of paramount importance to most of those injured. The majority were in heavy work before injury and an inability to return to their work forces them to do a lighter job. To a labourer this means a decrease in wages and he would not voluntarily accept this if he were able to do his former job. A return to light work usually indicated failure. For those involved in light office jobs before injury the assessment must be on the basis of the other two factors.

(b) The second factor used for assessment was the patient's ability to walk a mile. Each patient was asked this question and those who could not or said they might walk a mile but would have severe pain in their foot by that time were considered to be failures.

(c) The third factor was an assessment of the effect of the injury on the patient's personal life. If his symptoms were so constantly present and of such magnitude that he was continually aware of his foot, and could no more than manage his job, or found it necessary to pamper his feet each evening, he was considered a failure in this regard.

All patients who failed in at least two of the above factors (inability to return to heavy work, inability to walk a mile, and presence of overwhelming symptoms) were considered to have a poor result. If there was any doubt over the rating, the ability to return to their original work was of prime importance. Limitation of recreational activities was considered when there was difficulty in classification and particularly in those patients who had always been at a light job or had gone back to a light job due to higher financial remuneration. Many were limited in their ability to hunt, golf, bowl, dance, garden, run or play baseball and this limitation substitutes for the ability to return to work.

The fact that a patient was classed as a good result did not indicate that he was symptom-free, as only twenty-seven patients or 17 per cent had no complaints.

Results of assessment: Assessment of the 153

feet with fracture involving the subastragaloid joint with displacement of fragments reveals ninety-nine or 64 per cent with good results and fifty-four or 36 per cent with poor results.

The functional results were considered in relation to the treatment. In eighty-three fractures treated by conservative methods only sixty-three had good results and twenty resulted in poor function. In fifty patients treated by early surgical arthrodesis thirty had good results and twenty, poor results. (Table v.) It became apparent that the greatest percentage of good functional results lay in the conservatively treated group.

TABLE V
RESULTS OF TREATMENT

Type of Treatment	Total No. of Cases	Degree of Deformity		Results	
		Severe	Moderate	Good	Poor
Conservative	83	48 (58%)	35 (42%)	63 (76%)	20 (24%)
Surgical arthrodesis	50	35 (70%)	15 (30%)	30 (60%)	20 (40%)

TABLE VI
RESULTS IN PATIENTS WITH SEVERE DEFORMITY

Treatment	No. of Cases	Good	Poor
Conservative	48	34 (71%)	14 (29%)
Surgical arthrodesis	35	17 (49%)	18 (51%)

A more detailed examination was then made to determine if the severity of the fracture influenced the end result. Forty-eight of eighty-three conservative cases showed severe deformity and in this severe group thirty-four or 71 per cent had a good result and fourteen or 29 per cent had a poor result. In those treated by early surgical arthrodesis thirty-five patients had severe deformity of the os calcis. Seventeen or 49 per cent had good results and eighteen or 51 per cent had poor results. (Table vi.) This finding was in direct opposition to the opinion currently held that the cases of severe deformity are the ones requiring surgical arthrodesis or early operation.

Examination of the patient with moderate deformity produced the following results: In the conservatively treated patient thirty-five had moderate deformity of the os calcis. Of these twenty-nine or 83 per cent had a good result and six or 17 per cent had a poor result.

TABLE VII
RESULTS IN PATIENTS WITH MODERATE DEFORMITY

Treatment	No. of Cases	Good	Poor
Conservative	35	29 (83%)	6 (17%)
Surgical arthrodesis	15	13 (87%)	2 (13%)

In the group that underwent early surgical arthrodesis fifteen patients had moderate deformity. Thirteen or 87 per cent had a good result and two or 13 per cent had a poor result. (Table vii.) These figures are comparable and suggest that if any cases are to be chosen for arthrodesis those with moderate deformity would be better chosen.

It can be concluded from the above data that surgical arthrodesis has not improved the number of good functional results obtained from fractures of the os calcis in Ontario. Arthrodesis will be discussed in greater detail in a later section.

Twenty patients were treated conservatively after their injury and continued to complain of symptoms, or their symptoms became aggravated. This group then had a subastragaloid arthrodesis at one or more years after injury. At follow-up examination 70 per cent continued to have a poor functional result. This group is not included in the above end results as they were not personally examined by the examiner following their conservative treatment and cannot be considered failures in conservative treatment according to the criteria in this paper.

There were three cases of fractures involving the subastragaloid joint without displacement. This is a lower incidence than reported in other series. One had no immobilization and two were treated with plaster immobilization. Two had a good result and the other had a poor to fair result. They were back to work in an average of three months. It is generally concluded in the

literature that these cases do well. They do not require reduction or arthrodesis.

The cases treated by conservative means may be divided into two groups: (1) those treated by tensor bandage or by plaster immobilization and (2) those treated by manipulation, disimpaction, traction or other closed methods used to obtain reduction. A comparison of the final results in these two groups (Table VIII) indicates the degree of severity of injury to be comparable in each group. The group that was reduced had 72 per cent good results as compared to 81 per cent good results when no reduction was attempted. Table IX shows the results for severe deformities and it is evident that there is little difference in the results whether or not a manipulative reduction is performed. If anything, a reduction gives a lower number of good results.

TABLE VIII
RESULTS OF CONSERVATIVE TREATMENT

Type of Treatment	No. of Cases	Severe	Moderate	Good	Poor
Non-manipulated conservative	36	21 (58%)	15 (42%)	29 (81%)	7 (19%)
Manipulation or traction	47	27 (57%)	20 (33%)	34 (72%)	13 (28%)

If it is accepted that all of the pulling, pushing, pounding, immobilization and operating upon os calcis fractures has not produced any marked improvement in the results of treatment, it becomes apparent that we must reorientate our thinking away from attempting to fiddle with the comminuted fragmented bone and determine why results are poor. It may be rational treatment to persist in efforts to perfectly reduce a fracture of the radius but such a rule does not appear to apply to the os calcis. The question arises as to the value and function of the os calcis. A compound fracture of the left os calcis in a twenty year old labourer was treated conservatively. This became infected and a sequestrum was removed on two occasions. Finally, two years after injury the entire os calcis was removed. At ten year follow-up the patient has a good result with only minimal symptoms and is driving a heavy truck and carrying up to 250 pound weights. There is heavy callus under the loose heel pad but this is not painful. Cleminson [27], Leriche [28] and Pridie [29] have all presented satisfactory results following complete excision of the os calcis. Is the os calcis really necessary and how can it cause so much disability after fracture?

Assessment of End Results with Regard to Symptoms. Pain: In attempting to evaluate the cause of disability in fractures of the os calcis it is soon apparent that the most serious complaint is pain. Little attention has been given to the nature of the pain in the literature and there has been a tendency to group the various types of pain together. During the examinations of patients in this series it became obvious that there were several types of pain. The pain is related to both the hind foot and forefoot. The causes of pain in the forefoot are fairly obvious and less important. The causes of pain in the hind foot are more obscure. Most authors tend to relate this pain to the subastragaloid joint. This is obvious nonsense. Forty per cent of patients with surgically produced subastragaloid arthrodesis continued to have lateral malleolar pain or aching. In the conservative group there was no relation between pain in the hind foot and the presence or absence of a fibrous arthrodesis.

TABLE IX
CONSERVATIVE TREATMENT OF SEVERE FRACTURES

Treatment	No. of Cases	Good	Poor
Non-manipulated conservative	21	16 (76%)	5 (24%)
Manipulation or traction.....	27	18 (67%)	9 (33%)

A. Types of pain: The following pain patterns are noted: (1) Pain developed in the largest group during their daily activity or with any amount of constant activity. Often this pain did not start to develop until afternoon. Some patients appeared to have a tolerance for a certain amount of activity and could perform eight hours of work, but any extra work severely crippled them for the evening and often for the following morning.

(2) A few appeared to sublimate their pain or had no pain while on their feet. After sitting down or otherwise resting they had marked stiffness, and pain appeared on resuming activity. This is similar to the pain seen in various forms of osteoarthritis. Pain experienced when first stepping on the foot in the morning, with

improvement later in the day, was of this nature.

(3) In many patients immediate pain developed with pressure on the heel or other part of the foot. Although examination revealed no abnormal findings, a moderate amount of pressure produced severe pain, even though many years had elapsed since the injury.

(4) Other patients have little or no symptoms with ordinary walking or other activities but any action causing a sudden twist of the heel, such as stepping on a pebble, produced a sharp pain in the region of the os calcis. In some cases this was severe enough to make them fall. Two patients treated by conservative methods reported falling on uneven ground or even as a result of a small pebble on the smooth pavement. Nine of the patients with surgical arthrodesis reported falling. However the cause of falling did not appear to be pain in the majority of cases. The patient stated he would step on an uneven surface and suddenly fall. This appeared due to stiffness of the foot with an inability to adjust to uneven surfaces.

(5) A fifth type of pain is present at night and is described as a bursting, burning pain of a severe nature, present in the entire foot, but usually severest in the ankle and lateral malleolar region. This may or may not be present during the day. The feet usually swell during the day. This pain is uncommon but is a definite entity and was found in eleven patients, three having received conservative therapy and eight having been arthrodesed. Clinically this pain suggests a vascular disorder but this could not be demonstrated.

B. Site of pain: Pain occurred in the following sites: (1) *Heel:* In some cases the complaint is a mild aching located in the tip of the heel and present only with weight bearing. A fairly high percentage of patients with this form of pain have a marked deformity with reversed calcaneal angle or else a prominent and usually palpable bony exostosis on the bottom or side of the tuberosity. It seems reasonable that the reversed curve allows the body of the os calcis to strike the ground with weight bearing, particularly on rough surfaces, thereby producing aching and soreness. Removal of an exostosis improved the complaint in one case. Henderson [30] recommends chiselling the exostosis away to relieve pain. However, severe deformity and exostosis can be present with no symptoms. The presence of calcaneal spurs was shown to have no correlation to pain in the heel.

A second form of pain in the heel is present in a few cases causing much disability. This is acute pain on slight pressure and is localized at the tip of the heel or generalized over most of the heel. The pain occurs immediately on weight bearing. The origin is not clear but appears to be in the soft tissues.

(2) *Pain below the lateral malleolus:* This is the commonest site for pain and is the pain which causes the greatest amount of disability. The pain is located on the outside of the ankle and is usually localized below the lateral malleolus, either slightly anteriorly or posteriorly. It has been commonly said that this pain is due to damage and interference with the subastragaloid joint. The complaint may be of an ache in this region or of a steady disabling pain brought on by activity and particularly by activity on rough ground. This pain is present in the majority of patients in the early months after injury and disappears completely in many of the conservatively treated group at any time from six months to two years. In others it continues indefinitely.

Pain below the lateral malleolus is not typical of joint pain caused by arthritis. In some cases the pain is continuous on into the night. In addition there is usually a localized area of tenderness below the lateral malleolus. Thirty-six per cent of the patients with solid arthrodesis of the subastragaloid joint produced by early operation continued to complain of pain below the lateral malleolus. Forty-one per cent of the conservatively treated patients complained of pain below the lateral malleolus. Sixty per cent of these had partial or full movement in the subastragaloid joint. Forty-two per cent of those retaining movement in the subastragaloid joint complained of lateral malleolar pain.

These findings indicate that neither fibrous arthrodesis nor arthrodesis by surgical means seemed to relieve lateral malleolar pain.

Lateral malleolar pain does not correlate with impingement of the lateral malleolar tip against the talus or against lateral thickening of the os calcis. Careful comparison of clinical findings with radiological evidence showed no correlation whatever. Figure 2 shows marked lateral thickening of the os calcis as a result of the fracture and there would appear to be

obvious impingement of the malleolus with ankle movement. This man had definite pain below the malleolus. This excess bone develops in some patients and must be a response to abnormal stress. In this case the man had an arthrodesis and had no symptoms at follow-up examination.

TABLE X
ANALYSIS OF SYMPTOMS AS RELATED TO METHOD OF TREATMENT

Type of Treatment	Lateral Malleolar Pain	Heel Pain	Ankle Pain
Conservative:			
Subtalar movement, 50 (60%)	21 (42%)	13 (26%)	11 (22%)
Fibrous ankylosis, 33 (40%)	13 (39%)	9 (27%)	11 (33%)
Early arthrodesis, 50 cases	18 (36%)	19 (38%)	12 (24%)
Late arthrodesis, 20 cases	13 (65%)	6 (30%)	7 (35%)

It is our feeling that lateral malleolar pain is usually related to the lateral ligaments of the ankle joint and not to the amount of lateral thickening of the os calcis or to the impingement of this new bone against the lateral malleolus. Pretty [31] refers to this bone as excess callus and believes its formation can be prevented by a snugly fitting plaster.

(3) *Pain below the medial malleolus:* A pain or aching below the medial malleolus is a complaint noted in some patients. A few have pain below both malleoli and this seems to be distinct from those having pain through the ankle or subastragaloid region. There may be accompanying localized tenderness below the medial malleolus.

In the non-manipulative conservative group 11 per cent complained of symptoms below the medial malleolus while 9 per cent of the manipulated or traction group had symptoms as did 16 per cent of those with arthrodesis. This is a prominent symptom in only a few patients.

C. Site of pain as related to type of treatment: There were enough patients with complaints of pain to divide into groups according to their type of treatment and it was then found that each group complained of the same kinds of pain, no matter what treatment had been followed. In the patients treated conservatively 40 per cent had fibrous ankylosis and these were kept as a separate group. (Table x.)

FIG. 2. Lateral malleolar impingement. (Patient J. F., thirty-one years of age, returned to heavy work after injury. Complained of lateral malleolar pain but able to walk all day. Arthrodesis at sixteen months and has no improvement in the pain. Now on light job. Poor result.) Note lateral impingement.

The percentage of cases treated conservatively but with retention of joint movement and complaining of pain below the lateral malleolus was 42 per cent. In the cases with conservative treatment and fibrous ankylosis 39 per cent had pain below the lateral malleolus, 36 per cent after early surgical arthrodesis and 65 per cent after late surgical arthrodesis. Similarly with heel pain the incidence was 26 per cent, 27 per cent, 38 per cent and 30 per cent. In the same treatment groups pain occurred in the ankle in 22 per cent, 33 per cent, 24 per cent and 35 per cent respectively.

Almost all types of pain in the hindfoot, present in patients after fractures of the os calcis, have been attributed to damage to the subastragaloid joint. This would seem to be nonsense. It is probable that in some cases pain in the hind foot may originate in the subastragaloid joint but this is not necessarily or

even usually so. We have shown in this table that there is little difference in the distribution of pain in the hind foot whether there is movement in the joint or whether it has been destroyed, either by nature or by man.

D. Patients without pain: Twenty-seven patients or 17 per cent of 153 fractures had no pain whatsoever in their foot. To find such a small number of patients without pain is surprising. The clinical findings in each of these cases were examined for common factors. One-third of the fractures were graded as severe in type compared to two-thirds severe in the entire series. This suggests that fractures with minimal deformity tend to do better than the severe ones and this fact is well known. All of these patients had a good clinical result.

Eight patients were treated by tensor bandage or plaster, eight by manipulation or traction and eleven by arthrodesis. The ages ranged from nineteen to sixty-eight years and appeared of no importance. Two patients showed fractures involving the calcaneocuboid joint in the original files. The number of months from the time of injury to placing full weight on the foot was 2.5 in the non-manipulated conservative group, 3.5 in the manipulation or traction group and 4.4 in the arthrodesed group. These periods are one to three months less than for the total group. (Table III.) These people may bear weight sooner because they get better faster but it is my impression that early weight bearing is a good thing. It is also noted that these patients were immobilized for shorter periods than the average of all patients.

In the sixteen patients not treated by surgical arthrodesis, twelve had movement at the subastragaloid joint while in four a fibrous arthrodesis had developed. This should clearly settle the old wives' tale that a damaged subastragaloid joint always produces pain. In the group without arthrodesis there were no cases of stiffness of the ankle and foot, and no case of limitation of dorsiflexion to a right angle or less. In the eleven patients with arthrodesis six had stiffness and three dorsiflexion limitation. Five patients had a flattened longitudinal arch.

The author concludes that painless results do not tend to fall into any one treatment group. The pain may disappear even with severe deformity of the os calcis and with subastragaloid joint involvement. Correction of a flattened longitudinal arch or of a deformed os calcis is not necessary for a painless result.

E. The role of the subastragaloid joint in the production of pain: Almost all types of pain in the hind foot present in patients after fractures of the os calcis have been attributed to damage to the articular surface of the subastragaloid joint. Undue attention has been focused on this joint and reduction of the articular surface with lack of attention and neglect of investigation to the damage produced in other parts of the foot. Dick [7] describes pain in the heel on walking on flat ground and stabs of pain on irregular ground as due to traumatic arthritis of the subtalar joint. He recommends arthrodesis within three weeks if the subtalar joint is distorted by the fracture. Gallie [32] recommends arthrodesis for the following: "pain through the joint with walking and standing; acute twinges of pain when the heel strikes an uneven surface; marked limitation in the ordinary movements of the joint; and roentgenographic evidence of irregularity in the articulating surfaces." The author is unable to adequately define the pain caused by subastragaloid arthritis but for the purposes of discussion has referred to it as a sharp pain which can be produced by sudden inversion and eversion of the foot with the ankle at a right angle. This pain is described as passing through the centre of the area below the two malleoli. Subastragaloid joint pain is certainly not lateral malleolar pain as lateral malleolar pain is present in 40 per cent of the patients with surgically produced subastragaloid arthrodesis. (Fig. 3.) Similarly, it is not heel pain or medial malleolar pain. So we don't really know the clinical picture presented by pain from the subastragaloid joint. The subastragaloid joint may be a cause of the aforementioned pains but these pains do not go with subastragaloid arthritis.

The subastragaloid pain produced by inversion and eversion as just defined was present in eight patients in the conservatively treated group. Four of these had partial subastragaloid movement while the remainder had full movement. Four cases were rated as good in spite of the pain and four were rated as poor.

There were eighty-three patients treated by conservative means and fifty of these or 60 per cent had movement, complete or partial, at the subastragaloid joint. Thus 40 per cent had formed a fibrous arthrodesis following fracture.

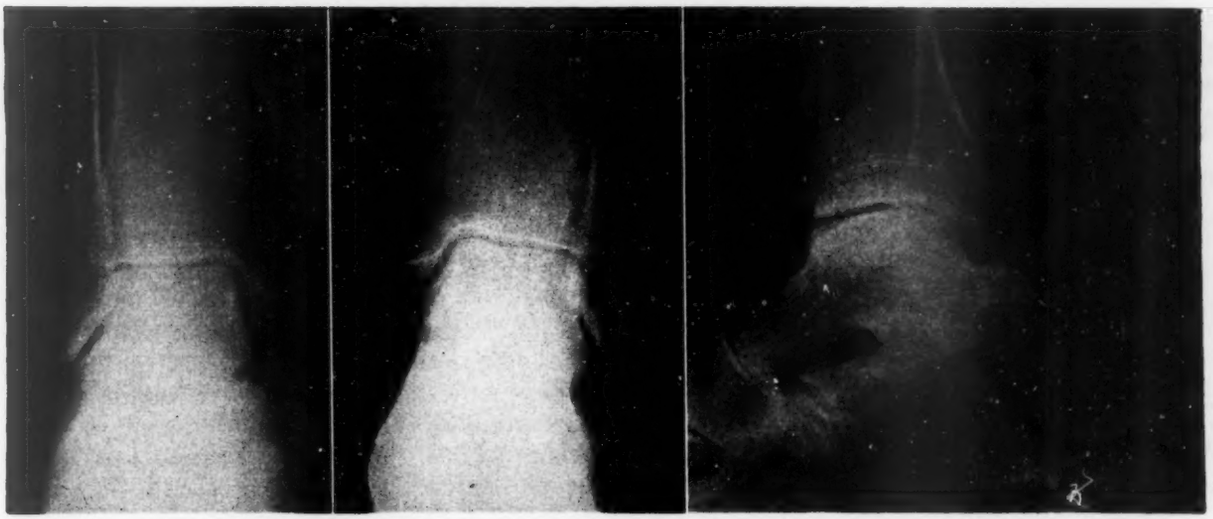


FIG. 3. Ankle pain. (Patient W. N., fifty-seven years of age. Severe fracture treated with arthrodesis at twenty-two months for lateral malleolar pain. At thirteen-year follow-up patient continues to complain of original pain produced by rocking the ankle. Poor result.) Note narrowing of ankle joint. Left view is normal foot.

There was no correlation between lateral malleolar pain and the presence or absence of fibrous arthrodesis. There was also no correlation between "good" clinical results and the presence of a subastragaloid fibrous arthrodesis. Thus we can find no evidence to support the statement, "A spontaneous sub-astragalar arthrodesis materially aided his early recovery." [3]

In thirty-seven cases or 45 per cent, subastragaloid arthritis was diagnosed on radiological evidence. This was based on the findings of narrowing of the joint space, sclerosis of the joint surface, osteoarthritic lipping at the anterior or posterior margins of the joint surface and irregularities of the articular surface. Six of these patients exhibited subastragaloid pain as defined heretofore. Three of these were good results and three were poor results. McFarland [24] reports a case with radiological evidence of marked arthritis in the subastragaloid joint but no symptoms and a good result at an early date. In this series radiological evidence of subastragaloid arthritis is not an indication for arthrodesis as it is not necessarily associated with subastragaloid pain and may be absent when the pain is a prominent symptom.

F. The ankle joint: Little attention has been paid to the ankle joint as a possible source of the disabling pain so commonly seen following os calcis fractures. It was thought that this joint merited further study. Accordingly both ankle joints were x-rayed in all patients so as to compare their appearance. Symptoms are present in the ankle joint in 20 per cent of all cases and are described as pain or aching developing across the dorsum of the ankle or passing through the ankle region. This is an area slightly above that described for lateral malleolar or subastragaloid pain. Aching in the ankle is often related to generalized tiredness throughout the entire foot. The form of treatment did not affect the incidence of ankle symptoms.

(1) *Pain in relation to radiological arthritis:* Twenty-one of the patients treated by conservative means and thirteen patients with arthrodesis showed evidence of osteoarthritis in the ankle joint. Five of the former and four of the latter had definite ankle pain. Among twenty-two conservative cases and twenty patients with arthrodesis with pain or aching in the ankle joint only seven of the former and four of the latter had radiological evidence of arthritis. This suggests that ankle pain is not related to evidence of osteoarthritis.

(2) *Rocking of the ankle:* Examination of the ankle joint revealed that some could be rocked from side to side when the talus and calcaneus were grasped as a unit and inversion and eversion carried out. This feature was occasionally present in a normal ankle but was abnormally common in the os calcis injuries. Table XI includes the incidence of ankle rocking in both conservatively treated patients and patients with arthrodesis. The greatly increased incidence in the group with arthrodesis

suggests that a subastragaloid arthrodesis may throw a greater strain on the ankle joint with compensatory increased movement in the ankle and an increased incidence of ankle pain.

(3) *Limitation of dorsiflexion:* In forty-five of the 153 cases the ankle could not be dorsiflexed to more than a right angle and in some instances did not reach this amount. This group represents 18 per cent of those with no pins or other operative procedures, 29 per cent of those with pins inserted and traction applied, and 39 per cent of those with operative arthrodesis. Twenty-three patients had poor functional results while twenty-two had good results. The operative trauma and longer immobilization probably results in greater limitation of ankle movement. There is more than one explanation of limitation of dorsiflexion. In some cases the tendo achillis is shortened. Tenotomy of the tendo achillis was not performed in any of these instances as has been done at other centers. In most cases the limitation was in the ankle joint itself. In one instance there was a decrease in the length of the circumference of the talar articular cartilage following subastragaloid arthrodesis. The bone graft inserted from behind tended to act as a bone block and limited dorsiflexion.

TABLE XI
ANKLE ROCKING

Treatment	Rocking	Ankle Pain and Rocking
Conservative	17 (20%)	7 (8%)
Arthrodesis	37 (53%)	17 (24%)

The cause of most fractures of the os calcis is a fall from a height with one force being transmitted through the tibia and one from the ground through the os calcis. If there is enough force to severely crush the os calcis there is probably enough force to cause damage to the soft articular cartilage in the ankle joint. This may be compared to the injury to the articular cartilage on the condyle of the femur in lateral tibial plateau fractures. Here, too, the damage is not visible in the roentgenogram. Two patients who both have severe pain after walking about 200 yards show ankle changes. Each uses a cane. Both have limitation of dorsiflexion and the former has pain on twisting of the ankle and one has some rocking movement. There is no ankle rocking in the latter. It appears reasonable that in these and other cases damage at the time of injury to the articular surfaces of the ankle joint has resulted in subsequent disability with degenerative joint changes. Similar degenerative changes with accompanying symptoms were not seen in any of the ankles on the non-injured feet.

G. Calcaneocuboid joint: Twelve per cent of the conservative group and 16 per cent of the group with arthrodesis showed fracture lines entering the calcaneocuboid joint in the original films. Follow-up x-rays of all cases demonstrated 14 per cent of cases with osteoarthritic changes in the calcaneocuboid joint. Only five patients had pain over the calcaneocuboid joint area. This included one with arthritic changes in recent films and two patients with no findings in any films. A patient treated by triple arthrodesis continued to have pain in this region. In spite of the development of osteoarthritic changes there would not appear to be merit in arthrodesis of this joint except in the occasional instance when pain can be attributed to the joint.

H. Taloscapboid joint: All cases of fracture of the talus were eliminated from this series to narrow the study to symptoms produced by os calcis fractures. No obvious damage was seen to the taloscaphoid joint in the original films. Of the eleven patients with minimal arthritis seven had no symptoms while two had lateral malleolar pain produced by a twist, one had numbness, and one had medial malleolar pain. Three complained of tiredness through the ankle area after activity. Twelve patients with marked arthritic changes included three without symptoms, four patients with pain produced by a twist, and two with lateral malleolar pain and three patients with aching pain through the ankle at the end of the day.

Ankle pain is prominent in these patients and it may be that pain can be referred to the general ankle area from the taloscaphoid joint. It would appear that early osteoarthritic lipping has no significance.

I. Peroneal tendons: Twelve people were found to have dislocation of their peroneus longus tendon from the notch behind the lateral malleolus. This results when the lateral thickening of the os calcis is marked, forcing the peroneus tendon out of its groove and

allowing it to ride forward onto the center or anterior portion of the lateral malleolus. Two of the twelve had soreness of the tendon at this site due apparently to the shoe or boot rubbing on the tendon. Two patients had definite peroneal spasm with pain in the muscle belly and the tendon standing out. These tendons were not dislocated.

Dislocation of the tendon did not produce symptoms unless it rubbed on the shoe. The cause of peroneal spasm in the two patients was not obvious. One patient had no other changes while the other showed gross osteoarthritis of the ankle without pain. It is often assumed that peroneal spasm may be an accompaniment of subastragaloid arthritis, but the two conditions were not found related. Conn [33] reports peroneal spasm present in every case in a series he followed.

Osteoarthritic lipping on the dorsal aspect of the taloscaphoid joint has been associated with peroneal spastic flat feet. These radiological changes were looked for and were present in some cases but showed no relation to symptoms or to peroneal tendon changes. Harris [34] blocked both the subastragaloid and mid-tarsal joints without relieving the valgus deformity attributed to the peroneal spasm in peroneal spastic flat feet.

J. Forefoot pain: This was in most cases related to forefoot disabilities. These include painful callosities, claw toes, varus or valgus deformities, hallux rigidus and stiffness. In only a few cases was forefoot pain a major symptom and it was not a main factor in determining a poor result. However, forefoot pain is not to be disregarded as some patients complained bitterly of this symptom. Nine patients had forefoot pain without obvious cause.

(1) *Callosities:* Callosities are usually related to a varus or valgus deformity of the forefoot. This is more obvious where the foot is stiffened. A slight valgus position tends toward a comfortable foot. About two-thirds of the valgus deformities were mild in degree. It has been noted that traction applied to a pin through the tuberosity often tends to cause a varus deformity of the heel. Others were arthrodesed in a varus position with resultant callus under the fifth toe and clawing of the toes. There were twelve cases of heavy calluses under the heads of two or more metatarsals with no accompanying varus or valgus deformity. All except one of these patients had been treated with wires, pins or arthrodesis and demonstrated a stiff foot on clinical examination.

(2) *Toe clawing and hallux rigidus:* Toe clawing was noted in fourteen patients and hallux rigidus in twenty-one patients with four patients having both conditions present. The hallux rigidus had usually not been observed by the patient and was painful in two cases only. All patients claimed that the toe clawing had arisen since injury and several attributed it to the Kirschner wire that had been passed through the metatarsal bones for traction with the triradiate traction wheel. The toes had fixed flexion deformities of the proximal interphalangeal joints with hyperextension of the metatarsophalangeal joints. This resulted in the tips of the toes pointing downward and developing painful callosities.

In this survey we have accepted Harris' definition of hallux rigidus [34] as an inability to dorsiflex the great toe beyond 45°. The cases of an exostosis present on the dorsum of the head of the first metatarsal just behind the articular surface, but with no stiffness, are also noted. Only two patients had associated tightness of the plantar fascia as mentioned by Harris. Pain was not a feature of the hallux rigidus but was present in two cases. Hallux rigidus with osteoarthritic change in these patients is probably due to chronic trauma to the metatarsophalangeal joint secondary to stiffness and deformity elsewhere.

K. Remarks: In this long-term follow-up study of pain in os calcis fractures certain features stand out. Stiffness of the forefoot can produce pain for several reasons as already outlined. Stiffness of the forefoot seems more common in patients treated by operation or by manipulative means. Prolonged immobilization also contributes to stiffness. It would seem that stiffness can be avoided.

There is no doubt that a definition of subastragaloid joint pain is extremely difficult if not impossible to obtain. If pain produced by the subastragaloid joint cannot be recognized there seems little point in fusing the joint for symptoms arising from other sources.

Most of these people have pain. The ankle appeared to be a cause of pain in some cases and the forefoot a cause of pain in other cases. The subastragaloid joint is not the cause of pain as has been supposed. We do not really know the cause of pain in the many remaining cases.

This narrowing of pain leaves much to be desired and much to be explained. The concrete fact is the tremendous trauma required to break the os calcis with this force transmitted on through the talus and in all directions—into the subtalar joint, the ankle, the mid-tarsal region and the forefoot. This must do tremendous and irreversible damage to all parts of the foot.

DISCUSSION OF METHODS OF TREATMENT

Reduction of Os Calcis Fractures. We have already stated that the attempt at closed reduction of the fracture of the os calcis is of doubtful value in relation to the results achieved. In addition, complications frequently result from insertion of wires or pins through the skin.

The incidence of complications occurring with closed reductions is worth recording. In seventy-six cases when adequate records were available the following complications were noted: In two patients suppuration developed at the site of the Steinman pin in the os calcis. In three patients drainage developed at the pin site in both the os calcis and in the tibia, with four operations for removal of sequestrae in the first patient, two operations in the second and one operation in the third. Two other patients had suppuration at the tibial wire site and one required sequestrectomy while the second underwent three sequestrectomies. An eighth patient had undergone two attempts at reduction and this was followed by sloughing of skin on the medial surface of the os calcis. This is an incidence of 11 per cent of patients with osteitis at the pin site of tibia or os calcis. Pretty [*31*] reported 7 per cent and Herman [*35*] stated in 10 per cent of their patients osteitis developed at the pin site in the os calcis.

At follow-up examination the length and width of both injured and non-injured foot was obtained. The results indicate a general trend only. A majority of patients were left with widening in the heel whether or not reduction was attempted. Only very few had heels narrower on the injured side than on the normal side. This was due to use of the Böhler clamp.

One of the effects of severe os calcis fractures is a shortening of the bone. Reduction attempts to bring this out to length. There was an increased number of patients with shortening of the injured side in each treatment group and this suggests that the os calcis was not brought out to its normal length in spite of attempts at reduction.

Reduction may be indicated in fractures with severe deformity and not too much comminution. Attempts at reduction in this series were generally unsuccessful and did not increase the percentage of good clinical results.

Immediate Surgical Arthrodesis. Arthrodesis of the subastragaloid joint was performed within one week of injury in four cases in this series. Three resulted in poor clinical results and one had a good result. Clinical follow-up demonstrated no features other than those already noted throughout the previous discussion of the remaining cases. There is difficulty in obtaining an arthrodesis in good position immediately after injury due to the severe comminution with mobility of the fragments [*7*].

Early Surgical Arthrodesis. This method of treatment for cases involving the subastragaloid joint is recommended by Dick [*7*] and others. Geckeler [*26*] states, "this operation, although radical, is dependable in preventing pain and minimising disability." He reports on twenty-seven patients with 70 per cent good results and no poor results.

Forty-six patients in this series had an arthrodesis of the subastragaloid joint without any prolonged trial of conservative therapy. For purposes of definition the group included all those who underwent arthrodesis within twelve months after injury. Except in an occasional instance the decision to operate was based on the radiological appearance of the fracture. Usually the indication for surgery was evidence of the fracture entering the articular surface of the posterior subastragaloid joint with displacement present. Sixty per cent obtained a good clinical result as compared to 76 per cent in a similar conservatively treated group. In spite of disabling symptoms and inability to do heavy work many patients were pleased with their result as they had been told at the time of the injury that they "would never walk again" or that "the leg should come off." Only one case of arthrodesis appeared not to be fused at follow-up examination. A subastragaloid arthrodesis with posterior approach does not always permit correction of a varus deformity.

The clinical findings in surgical arthrodesis have already been discussed. The following observations are of interest.

Donor site: Tibial bone was used in 57 per cent of cases with ilium in 25 per cent, bone bank in 2 per cent and in 16 per cent no graft was used. Eight per cent complained of numbness in the donor area; an equal number of aching with weather changes and 14 per cent of tenderness when the area was struck. Five per cent complained of constant soreness and these were patients with iliac donor sites. Their pain suggested a muscular origin. In one patient a stress fracture developed at the tibial donor site four months postoperatively.

Complications of arthrodesis: In 133 cases of subastragaloid arthrodesis, available records were adequate to determine the early operative complications. Some of these patients could not be followed up due to death or loss of contact. Six patients (4.5 per cent) required a second operation for refusion due to failure of the first arthrodesis. Three of these patients had reduction and then had three subsequent operations for arthrodesis. Another patient required two sequestrectomies. Other minor complications recorded include two postoperative infections with incisional breakdown and one case of abscess at iliac donor site.

Operative scar: Four patients complained of callous formation in the scar causing irritation from their shoe.

Numbness: This was a bitter complaint at follow-up in sixteen of the series and all of these patients were treated by wires or pins driven through their foot or with a surgical arthrodesis. It would appear that the sural nerve fibers may be crushed or traumatized with the initial injury and patients will complain of numbness of the foot. This early numbness subsides and is not a complaint at follow-up examination. In some patients whose feet are operated upon, numbness continues to be a complaint years later. This is almost always located along the lateral side of the foot extending over the lateral side onto the dorsum. The foot is said to feel dead but seldom can any objective loss of sensation be demonstrated and the symptoms are really paraesthesias. In one case, with a trigger point below the lateral malleolus causing electric shocks down the foot, operative removal of a "neuroma" failed to improve the situation.

Late Surgical Arthrodesis. Twenty patients were given a trial of conservative treatment for over one year and then underwent subastragaloid arthrodesis.

The following are the reasons for late arthrodesis with results obtained.

Lateral malleolar pain: This was the main reason for arthrodesis in nine cases. Of sixteen patients in whom records show lateral malleolar pain to be present before fusion, two were cured and fourteen continue to have this symptom. Three have been improved by 50 per cent and one has pain twice as bad as before the operation. One now has this symptom in whom it was not mentioned before operation.

Arthrodesis: Arthrodesis was performed in three cases for subastragaloid pain as defined in this article, i.e., pain with inversion. Follow-up examination revealed a solid subastragaloid fusion and each patient continued to have pain produced by attempt at inversion. This appeared to be localized to the ankle joint.

Falling: Three patients had this symptom. One continues to fall while another is cured of this, and the third does not admit to falling but cannot go on rough ground and must watch his walking at all times.

Ankle pain: Two patients had pain through the ankle before operation and this improved in one patient.

Heel pain: Four patients were operated upon for this symptom and all continue to complain of pain in the heel.

No definite reason could be found for surgery in two cases other than on a radiological basis. One man was back at heavy work. The other stated he was advised to have the operation after a veteran's examination although he was carrying on at his former job without trouble.

As we did not have the opportunity to examine these patients before operation it would be unfair to say they were not improved. In fact 70 per cent thought they were improved. Nevertheless, according to our classification of function in relation to activity 70 per cent continued to have poor results.

White and Harris [*36*] reported nineteen out of forty-three patients treated by reduction who had unsatisfactory results at follow-up examination. They all complained of pain beneath the external malleolus. Apparently some had not been able to go back to work. These patients were then treated by subtalar arthrodesis and returned to work (not necessarily heavy work) in an average of twenty weeks.

Late subastragaloid arthrodesis is probably indicated in the treatment of some fractures of the os calcis with persistent "subastragaloid"

pain. It is not indicated for lateral malleolar pain, heel pain, or ankle pain. Pain suggestive of origin in the subastragaloid joint as indicated by inversion and eversion tests must be carefully distinguished from pain originating in the ankle as this is a likely source of error. Radiological osteoarthritis of the subastragaloid joint is not an indication for fusion.

Triple Artbrodesis. Conn [33] condemned subastragaloid arthrodesis in favour of triple fusions because the subtaloid and mid-tarsal joints function as one unit and simple subastragaloid arthrodesis failed to yield satisfactory feet in at least one-third of the fresh and one-half of the late lesions. He cites twenty-six old cases, all with pronation of the heels, planus of the long arches, and valgus of the forefeet with persistent disabling pain, while twenty-five new patients treated by Conn with triple arthrodesis had good to excellent results in all but three instances.

In this series four patients had the calcaneocuboid and taloscaphoid joints fused, and in one case only was the calcaneocuboid joint fused following the original injury. These cases were classified as good in one patient treated at age sixteen and poor in the other four cases. One of the four had a triple arthrodesis at one week after injury and required refusion nine months later. Osteoarthritic changes were marked at the scaphocuneiform joint in one patient on follow-up examination.

COMMENTS

The findings in this series raise many interesting points for discussion. In view of the many opinions of other authors, a few comments seem appropriate.

The author regrets that a detailed study of this series has not solved the problem of disability in fractures of the os calcis. It is hoped that this study will result in a reorientation of our thinking and will stimulate a study of the soft tissues in relation to pain. There has been a preoccupation with the articular surface of the os calcis which has resulted in a tendency to attribute all symptoms to this area and a concentration on correcting or altering the joint surface. The dictum "Old painful fractures call for a double or a triple arthrodesis" [3] is not valid.

Attention must be directed toward the origin of lateral malleolar pain. If this arises from chronic ligamentous strain, it should be possible to produce alleviation if not cure. In the past it has been attributed to impingement of the lateral malleolus against the thickened os calcis and in some cases the "scoop" operation has been performed to remove the excess bone. In this series four such operations were performed, three of them being part of a late subastragaloid arthrodesis. Two cases were classified as good results on follow-up and two cases were poor. Pretty [31] did not find the scoop operation satisfactory. Henderson [30] recommends it. Our findings indicate no correlation between lateral malleolar impingement and lateral malleolar pain.

Dachtler [37] and Bradford [38] have each discussed the marked disability following fracture of the anterior-superior portion of the os calcis by indirect violence. This often-missed minor fracture can produce pain out of all proportion to the amount of bone displacement, and disability has been known to last up to eighteen months and usually for five or six months. The pain is accompanied by acute tenderness and is localized to an area "just below the level of the tip of the lateral malleolus and approximately two fingers-breadths anterior to it." The degree of pain cannot be related to bony change alone and must result from soft tissue injury. This suggests that a similar pain mechanism may be present in more severe fractures of the os calcis. Bradford suggests that the fracture site lies at a trigger point causing repeated painful stimuli resulting in a form of causalgia.

The pain fibers from the region of the lateral malleolus travel through the sural nerve, and others pass with the sympathetic fibers along the vascular tree. From evidence available the results of lumbar sympathetic blocks in this series have not been encouraging. In one case a neuroma of the sural nerve was excised without improvement of lateral malleolar pain.

Conn [33] discusses luxation of the taloscaphoid joint as commonly occurring and being due to rotation of the talus which follows the flattening of the os calcis. Examination of this series showed variations in position of the talus relative to the scaphoid which suggested luxation. However this bore no relationship to residual pain and was finally discarded as a factor of no importance.

Consideration has been given to the relationship of the traumatic flat foot to the residual disability. Essex-Lopresti presents a twenty-

three year old serviceman with rigid, painful flat foot as a tragedy of failure in treatment and states that he is crippled for life and "condemned to two sticks and a sedentary life." In this series with many severe fractures, only four older men were left using canes. Traumatic flat feet were not found to be related to permanent disability. The longitudinal arch was examined in each patient and was compared with the arch on the uninjured foot. Thirty per cent of the conservatively treated patients and thirty-one per cent of the patients treated by arthrodesis had flattened arches, with about one-third of each being mild flattening and the remainder severe. Five per cent of the patients had flattened arches bilaterally. The patients with flattened arches were about evenly divided between the good results and the poor results.

Harris [*34*] investigated flat feet in relation to disability in army training. He found disability for army drill in cases of hypermobile flat feet with short tendo achillis and was able to correlate this to some extent with the amount of support given by the body of the calcaneus to the head of the talus. He attributed the symptoms to greater stress on the ligaments due to a decrease in support of the head of the talus. This latter observation was based on clinical judgment as he was not able to satisfactorily demonstrate a constant change in relationship on the roentgenograms. Many of our patients showed limited dorsiflexion of the ankle. In a fair proportion of instances this was due to a short tendo achillis. Harris noted the increased strain this condition puts on the mid-tarsal joints with subsequent joint changes. Most of the literature has stressed a lengthening of the tendo achillis due to upward displacement of the tuberosity and suggested this as a cause of weakness of plantar-flexion. The author could not confirm these results and cannot explain the shortening of the tendo achillis. Limitation of ankle movement in the majority of cases was due to changes in the ankle itself.

Some attention was given to the relation of the axis of the talus to the os calcis. There was an impression that in many of the severe cases the talus was in a dorsiflexed position compared to its normal relation with the os calcis. This would limit dorsiflexion. In the normal case a line drawn through the posterior-superior point of the calcaneal tuberosity to the antero-superior portion of the os calcis meets a line through the axis of the talus at *25* to 30 degrees. Review of the x-rays showed many patients with this angle reduced to *15* degrees or less. The cases with poor clinical results showed a wide variation in the angle. Rotation of the talus in the opposite direction to the above would place it in relative plantar-flexion to the os calcis. This change was unusual.

The series of cases treated with tensor bandage alone is not large enough upon which to base conclusions but a review of these cases certainly suggests that little or no immobilization results in less stiffness. We endorse the trend toward less immobilization as discussed by Essex-Lopresti [*17*], DeBold and Stimson [*40*], and Day [*20*].

The purpose of this study was to compare results obtained through various methods of treatment of fractures of the os calcis. On the basis of the information presented here, patients treated by various forms of reduction and by both early and late surgical arthrodesis of the subastragaloid joint, show no better results than those treated with tensor bandage alone or with plaster immobilization. In fact tampering with the fracture or fusing the joints of the foot gives a greater number of poor results than does conservative treatment.

Undue attention has been focused on the subastragaloid joint and many symptoms have been attributed to irregularities or arthritis in this joint which in fact have no relation at all to the joint. This is borne out by a study of patients with solid arthrodesis of the subastragaloid joint who have essentially the same symptoms as have those with conservative treatment. A study of conservatively treated patients who have gone on to form a fibrous arthrodesis of this joint shows that this has no relation to the final result.

The major cause of disability in fractures of the os calcis is pain and this may be of several types and in several locations. Little has been learned about the cause of this pain or how to relieve it but the nature of the pain suggests a soft tissue origin and research is required into the part played by the ligaments of the tarsal joints and by scar tissue resulting from the fracture.

Other causes of disability include varus or valgus deformity of the heel or forefoot, stiffness of the forefoot, limitation of dorsiflexion, callosities, claw toes and numbness. Severe

flattening of the longitudinal arch showed no correlation with good or poor results. Peroneal spasm was uncommon. Impingement of the lateral fibular malleolus on the laterally thickened os calcis is not usually a cause of lateral malleolar pain.

Attention is drawn to the ankle joint as a source of pain. Damage may occur to the articular cartilages at the time of injury or increased stress on the ankle may cause degenerative changes. Radiological evidence of osteoarthritis in the ankle does not correlate with pain in the ankle. In some cases arthrodesis was performed for subastragaloid pain and postoperatively the same pain was present and appeared to come from the ankle.

Attempts at reduction of the fracture displacement did not increase the percentage of good results in this series. Only 33 per cent showed radiological evidence of improved position of the fragments. A failure to obtain perfect reduction did not alter the prognosis. Eastwood [*39*] came to similar conclusions to those in this paper and said "Plaster fixation alone gives results which compare very favourably with any other method of treatment, although it cannot be described as consistently successful."

SUMMARY

1. Three hundred ninety case histories of old fractures of the os calcis were examined. Thirty per cent showed no involvement of the subastragaloid joint. A follow-up was carried out on all those involving the joint and it was possible to examine one hundred forty-seven patients with an average of eight years since injury. These were treated by various surgeons throughout Ontario. Treatments included therapy without immobilization, and plaster immobilization; manipulative reduction or traction reduction; and surgical arthrodesis. The series for each type of treatment were comparable as they contained approximately the same percentage of moderate and severe injuries.

2. *Results:* Considering the fractures into the subastragaloid joint with displacement, 76 per cent of the conservatively treated and 60 per cent of the arthrodesed group had good results. Seventy-two per cent of cases with closed reduction were good as compared to 81 per cent of those with no reduction.

3. Neither age nor sex appeared to affect the prognosis. Flattening of the longitudinal arch is not related to the result. An inability to toe walk, a chronic limp and the presence of oedema correlate with a poor result. Attention is drawn to the hard surface necessary to produce a fracture with displacement. Emphasis is placed on the slow improvement in symptoms with some improving for ten years and with some cases having temporary relapses. In six per cent increased symptoms have developed after several years.

4. The major symptom of pain is differentiated into five types and five locations. Lateral malleolar pain and heel pain are the chief sources of disability and both seem related to soft tissues and are not relieved by subastragaloid arthrodesis. Pain in relation to the calcaneocuboid and taloscaphoid joints is less common and not a serious source of disability. Ankle pain is present more often than is realized and 27 per cent had pain or aching in the ankle either continuously or after being on the foot for some time. Ankle symptoms did not correlate with osteoarthritis of the ankle.

5. A study of those patients who had no pain on follow-up revealed no consistent finding to explain the absence of pain. All methods of treatment were used in this group. Many of these patients were found to have uncorrected deformities such as flattened arches and thickened heels. The presence of subastragaloid movement in the subastragaloid joint indicated that a fibrous ankylosis was not necessary for the foot to be pain-free.

6. Complications of operative therapy are recorded. Eleven per cent of those with traction applied through pins developed sepsis. Four point five per cent of cases treated by arthrodesis required one or more refusions.

7. Twenty patients with persistent symptoms after conservative treatment had a surgical arthrodesis. Seventy per cent continued to have a poor result. An analysis of the reasons for fusions suggests that a better understanding of pain relationships could improve these results. Arthrodesis is only rarely indicated in failures of conservative therapy.

8. A plea is made for reorientation of our thinking in relation to pain in fractures of the os calcis and for investigation of the soft tissue etiology of residual pain in os calcis fractures.

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DISCUSSION

President Johnston (Detroit, Mich.): Dr. Lindsay, how were you able to get such widespread and detailed information about all these things? Tell us, how do you get these data together? It looks like a lot of material.

W. R. N. Lindsay: This is the first of a series of studies being sponsored by the Workmen's Compensation Board of Ontario—not entirely the Compensation Board, but drawn from the files of the

Toronto General Hospital and the Compensation Board files. We started out to obtain a large group of follow-ups and found that the patients would not come in for check-ups for many reasons.

First of all, they did not want to miss work. Secondly, many of them felt they had received all the treatment they could have. Clearly, some of them were not happy with the result and did not want to come back. Unfortunately, many felt their pensions might be cut.

Finally, many of them had been told that they would never walk again and felt that they had a wonderful result because they could walk. So, they remained at home and didn't come in to be seen or examined.

It was considered, therefore, that in order to have a series in which we were not getting weighted good results or weighted poor results, it was necessary to travel throughout the Province. This study involved a 5,000-mile trip to see these people in their homes and examine them and take x-rays. Every patient reported on had x-rays at the time of examination. All but three were personally examined.

PRESIDENT JOHNSTON: We would like to see more studies of this type and more in the field of trauma.

ALBERT W. MCCOLLUM WHITE (Toronto, Canada): I am glad to be allowed to speak at this point because, to me, it is a delight to be able to congratulate a home-town boy for a paper of such quality. You realize, of course, the tremendous amount of work he has put into this subject.

The fact that he, personally, had to travel 5,000 miles to find these people so that their cases could be followed up, I think indicates the sort of effort that he has made. The paper shows, I believe, how beautiful theories can be cut down to size by a set of ugly facts. It tends, perhaps, to produce a feeling of frustration in the treatment of this serious injury.

I am sure Dr. Lindsay would not wish to have us discard all the ideas we have gained throughout the years in trying to decrease the permanent disability following the fractures of the os calcis, but rather to fit our ideas more accurately into their proper places.

Certainly, the great question which remains is to try to determine the cause of continuing pain. I have no doubt that such things as reduction of a deformity, and subtarsal or triple arthrodesis will continue to be useful. But, I would hope that this work will stimulate us to work with more careful vision and gain a clearer picture of the problem so that its solution may be much more accurate in the application to the individual case.

Once more, may I present our sincere appreciation to Dr. Lindsay.

Immediate Moore Prosthetic Replacement in Acute Intracapsular Fractures

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SINCE the introduction of replacement arthroplasty by the Judets in 1950 [5,6], suggestions have been voiced and attempts made to apply this principle in the immediate treatment of fractures of the femoral neck. Since a number of such intracapsular fractures eventually come to arthroplasty because of non-union or aseptic necrosis, immediate replacement has been suggested and carried out by d'Aubigne, Creegan, Day, Petersen, Thompson, Moore and others [1–3,7,8,11].

TABLE I
OPERATION BY YEAR

	1951	1952	1953	1954	1955	1956	1957 (6 mo.)
Service.....	1	2	2	7	14	22	11
Private.....	0	2	1	2	12	8	8

Since 1938 it has been routine on the Trauma Service of the Third (New York University) Surgical Division of Bellevue Hospital to undertake early operative internal fixation of fractures of the femoral neck. Siris and Ryan [9] in 1944 and Siris and Mulholland [10] in 1947 documented experiences with over 300 cases. The hospital mortality rate (9.6 per cent) and the rate of significant complications (25 per cent), which includes both aseptic necrosis and non-union, were similar to other reports.

The problem of one poor outcome in every four patients remained. Conventional hip fusion operations, which enforce prolonged immobilization in a spica cast, were unsuitable. From 1948 to 1951 subtrochanteric lateral wedge osteotomies with internal fixation were performed in a selected series of thirty-five patients with unstable intracapsular fractures of the femoral neck (those corresponding to Pauwels' class III). The outcome of this trial was disappointing. Results were good in less than one-third of the cases, fair or poor in more than one-third, and there was a hospital mortality rate of 26 per cent.

TABLE II
SOURCE OF PATIENTS

	Service	Private	Psychiatric	Total
Male.....	20	4	7	31
Female.....	39	29	16	84
Total.....	59	33	23	115

Immediate prosthetic replacement was first utilized in 1951. (Table I.) The early patients were selected on the basis of poor risk for prolonged convalescence or pathological fractures. In addition to these cases thirty-six arthroplasties were carried out for non-union or aseptic necrosis, a group not considered in this paper.

The patients upon whom this series is based were from two sources, two-thirds from the Trauma Service of the Third Surgical Division of Bellevue Hospital, and one-third from the private practice of the senior author. (Table II.) Twenty-three inpatients from the Bellevue Psychiatric Hospital have been excluded from this series because they are an unusual group not comparable to a normal hospital population.

The ward patients were typical of the patient load seen in any large municipal institution. Many were aged (average age 73.5 years) and debilitated people living on small pensions or

maintained by the Department of Welfare. They suffered from concomitant disease, senility and many were clinically malnourished. Among the younger patients there were a number of chronic alcoholics. On the other hand, the private patients were a relatively well

TABLE III
DISTRIBUTION OF PATIENTS ACCORDING TO AGE

	Decade					Average Age	Oldest Patient	Youngest Patient
	50–60	60–70	70–80	80–90	90–100			
Service..	4	18	18	18	1	73.5	92	58
Private.	4	5	12	10	1	74.7	91	51

preserved group. While they were on the average older than the ward patients (74.7 years), and while the same percentage of them suffered from concomitant diseases, they manifested better attention to their medical problems and a better state of nutrition. (Table III.)

The selection of cases for immediate replacement arthroplasty in fractures of the neck of the femur was made on the basis of the morphology of the fracture and a consideration of the age and the general state of the patient. All these cases represented displaced intracapsular fractures, either subcapital or high transcervical, usually of the unstable (Pauwels' class III) type. The patients were usually over sixty-five years of age or represented a physiological state comparable to that age group. A special category is the pathological fracture.

A pathological fracture or an unrelated fracture of the hip occurring in a patient with known disseminated malignant disease is considered an absolute indication for prosthetic arthroplasty. This procedure permits prompt weight bearing after operation and preserves people of obviously limited actuarial life expectancy from the possible complications of unsuccessful nailing of the hip. Eight such patients were treated. Following are the details of one case:

F. D. (B. H., No. 67126-56), a fifty-eight year old woman who had been on steroid therapy for two weeks for "arthritis of the left hip joint," suddenly collapsed. On admission to the hospital she was found to have a transcervical fracture of the left femur through an osteolytic area. A hard mass was found in the right breast. Biopsy of the lytic area in the femur performed during arthroplasty showed metastatic carcinoma from the breast.

Three weeks after arthroplasty, by which time the patient was ambulatory, a simple mastectomy was performed, followed by radiation. Ten months after operation the patient was fully employed as a secretary and ran her own household. She walked well without pain or limp although she had been advised to use a cane while walking in the street.

TABLE IV
TYPE OF PROSTHESIS

	Service	Private
Judet	7	4
Thompson	1	0
Moore	52	29

The method of treatment and choice of prosthesis has been a slow evolution. (Table IV.) In the early cases a Judet prosthesis was used with the Smith-Petersen anterior approach. In one case a Thompson prosthesis was used. Since January, 1954, a modified Moore arthroplasty, utilizing the Gibson modification of the Kocher approach [4], has been used. For the actual operation an Albee-Comper table, which incorporates a horizontal perineal post in conjunction with a pubosacral vise, is used. This stabilizes the patient in the lateral decubitus position more securely than does adhesive tape strapping on an ordinary operating table; it avoids respiratory embarrassment and affords better access to the operative field without limiting manipulation of the injured limb.

All patients have padded plaster boots carefully applied the day before operation. Following the operation with the patient still in fixed position on the table, the casts are interconnected by a crossbar with the operated leg abducted and in internal rotation. Since this practice has been in use, there have been no dislocations. There is danger of pressure sores of the heel and in one instance foot drop was caused by a poorly applied cast. The frequent occurrence of pressure areas on the heel has led to a consideration of another approach which will dispense with the boots. Moore's "Southern Approach" [7] is perhaps an answer. In the latest three cases a further modification of the Gibson approach has been employed

without application of boots. These patients have done well.

The mortality following operation has varied greatly between the private and service patients. (Table v.) By the nature of the type of patient for whom this operative procedure is reserved we have divided the mortality into operative and late mortality. The operative mortality consists of those patients who died within thirty days of operation. Late deaths are unrelated to the operation and are recorded as part of the follow-up from thirty-one days to three years postoperatively.

Stress is placed on the fact that none of the patients who were classified as not suffering from severe intercurrent disease died in the period either immediately after operation or during the follow-up.

TABLE V
MORTALITY

	Service	Private
Operative and up to 30 days post-operatively:		
Pulmonary embolism	2	1
Bronchopneumonia	3	0
Delirium tremens	1	0
Myocardial infarction	1	0
Unexplained death in recovery room	1	0
Uremia (4 yr. following Whipple operation for carcinoma of ampula of Vater)	1	0
Electrolyte shock (4 mo. after bilateral adrenalectomy for metastatic carcinoma of prostate)	1	0
Totals	10 (17%)	1 (3%)
Late (over 30 days and up to 3 yr.):	15 (25%)	6 (18%)

TABLE VI
COMPLICATIONS

	Service	Private
Decubitus ulcers	7	2
Pressure sores of heels	2	3
Pneumonia	6	2
Wound infections (septicemia 2, both patients survived)	5	0
Severe genitourinary infection	1	0
Congestive heart failure	3	3
Intestinal obstruction	1 (cancer of ovary)	1 (volvulus)
Dislocation	1 (no boot)	0
Foot drop	1	0
Contracture	0	1
Cerebrovascular accident	0	1
Phlebitis	0	1

TABLE VII
FOLLOW-UP

	Service	Private
Excellent (walking without support; no pain or limp)	11	11
Good (walking with a cane; no pain; minimal limp)	7	9
Fair (walking with a cane or crutch; occasional pain; minimal limp)	10	5
Poor (walking with a crutch; with pain and limp)	6	3
Follow-up	34/34	28/28

Considering the population undergoing treatment the complications for the most part are self-explanatory. (Table VI.) Despite antibiotics, pulmonary infections are frequent. These are usually hypostatic rather than of the classic lobar type. Decubitus ulcers are troublesome. In some cases the ulcers were present when the patient was admitted.

There were no infections in the private cases. In those cases treated by the house staff on the ward service there were five soft tissue infections. No instances of osteomyelitis were encountered. Two patients had septicemias, one pyocyaneus and one Staphylococcus aureus coagulase positive; both survived with antibiotic treatment. In no patient was it necessary to remove the prosthesis because of infection. All recovered and did as well as the patients without complications.

Follow-up has extended from five months to six years. (Table VII.) All thirty-four survivors of the service patients were followed-up for a varying period of time. In the private series the follow-up is complete.

Considering this particular group of patients, the aim we set out with and the criteria that we used for the evaluation of these patients, the excellent, good and fair results must be considered satisfactory. Of the surviving patients, 85 per cent have done satisfactorily and 15 per cent have had failures.

SUMMARY

Ninety-two cases of displaced subcapital and high transcervical fractures of the femur were treated by immediate Moore prosthetic replacement. These patients were mostly past the sixth decade of life. In both the service and private patients the procedure has been satisfactory. Surgical complications have been minimal, and morbidity and mortality are comparable to that of simple Smith-Petersen nailing. The disappointments of aseptic necrosis and mechanical failure that accompany the latter procedure have been avoided. Prosthetic replacement in individuals of waning years for displaced intracapsular femoral fractures is a rational step in the difficult problem of fractures of the hip.

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Fractures of the Hip—Mortality Survey

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THE problem of the fractured hip, the unsolved and apparently at least partially unsolvable fracture, is one which has received so much attention in the medical literature in the past generation that one hesitates to add still another paper. However, at serious risk of being obvious, this paper is intended to emphasize the fact, of which we are all quite aware, that the unsolved fracture is not a single problem but rather constitutes two problems, each serious, each difficult to manage and each unsolved. There is the problem of the fracture itself, its treatment and the appropriate means of securing eventual union. The problem of survival of the elderly patient with a hip fracture is one which is at least equally difficult, and from a broad point of view certainly more important.

A very cursory and incomplete review of papers on the subject of hip fractures published in the five years ending in 1956 and appearing in orthopedic, general surgical and general medical journals reveals a total of 141 papers on the subject. Of these papers, only eleven discussed the subject of patient survival with more than a mere mention, and only six of these 141 papers were devoted to the subject of patient survival. Without attempting any tedious discussion of any of these previous papers, one can conclude from them that the treatment of the fracture itself has improved quite appreciably in the past several years and the incidence of union has definitely risen; on the other hand, all the available evidence seems to show that the mortality rate for all patients, in unselected series of cases, has not appreciably improved in the past ten years or more in spite of many assumed advances in general patient care.

This present paper is a summary of a detailed statistical analysis of 146 consecutive patients with fractures of the hip treated at St. Luke's Hospital in Bethlehem, Pennsylvania, during the four years from 1952 to 1956. Many of these patients are from the authors' private practice; the others were treated by other members of the staff, both orthopedists and general surgeons. We have purposely excluded from this survey a group of six patients under fifty-five years of age who also had hip fractures; it was not thought that survival presented any problem in patients in this age group. We have also excluded from the present series a few cases of pathologic fractures of the hip due to metastatic disease; here again, the question of survival is an entirely different one. Excluded also are the cases of fracture involving only the greater trochanter and requiring no treatment other than protected ambulation. With these exceptions, the records of every patient admitted to our hospital during these four years with a fractured hip of any type are included in this paper.

TABLE 1
REPORTED MORTALITY RATES

Fahey, Kilfoyle and Shortell, 1949 [1]	
100 unselected patients age 70 or over	
Gross mortality	23%
Operative mortality	18%
Schenk, Smith and Stephens, 1956 [2]	
239 unselected cases	
Gross mortality	32%
Operative mortality	26%
Present series	
140 unselected patients age 55 or over	
Gross mortality	29%
Operative mortality	26%

Our patients are completely unselected; and since ours is the only general hospital in our city, we have to accept patients from every source. These include private patients, charity patients, and a fairly large and apparently increasing percentage of patients who come from nursing homes, the county home and a large state psychiatric hospital located nearby.

Table 1 serves to illustrate two simple facts

about our present series. First, it is apparent that our survival figures are not especially good, with almost a third of the entire group of patients not surviving, and a quarter of the operated patients dying before they could be discharged. Second, it illustrates the fact that

TABLE II
MORTALITY BY AGE GROUPS

Age	No. Admitted	No. Who Died	Mortality Rate (%)
Under 55.....	6	0	0
55–64.....	20	2	10
65–74.....	33	5	15
75–84.....	60	20	30
85 and over....	33	15	45

TABLE III
YEARLY MORTALITY RATE VERSUS AGE DISTRIBUTION

Years	Patients over 75 Yr. (%)	Patients Who Died (%)
1952–1956	64	29
1952–1953	67	28
1953–1954	70	30
1954–1955	78	42
1955–1956	52	20.4

similar figures are reported from other general hospitals, where the patients are taken without any means of selection at all. Many other series of cases have been reported with much lower mortality rates, but these would appear to be, in most cases at least, highly selected groups.

Table II shows the mortality rate for our series, divided into various age groups. It shows the rather striking but not unexpected increase in mortality with increase in age. The average age of the survivors in our group was seventy-two, while the average age of those patients who died was eighty-one. When all our statistics are analyzed, it becomes quite apparent that no single factor influences the prognosis in any given case quite as markedly as does the simple fact of the patient's age.

Table III illustrates the variation in mortality rate which we have experienced in various annual periods. It will be seen that there is a considerable difference in the mortality rate from one year to another, but that for the most part this variation parallels quite closely the proportion of patients in the risky age group over seventy-five. It is of interest to note that starting with the 1955–1956 period we instituted a type of team approach to the care of these patients, leading to presumably more

TABLE IV
MORTALITY RATE VERSUS PREVIOUS INVALIDISM

	No. Admitted	No. Who Died	Mortality Rate (%)
Active persons....	95	18	19
Invalids and semi-invalids.....	51	24	47

efficient use of the talents of the surgeon, the anesthesiologist, the internist, etc. We had hoped that use of this approach would result in an appreciable improvement in patient survival figures. To be sure, the mortality rate for this particular annual period is less than half of the mortality percentage for the preceding year; however, noting the great difference in the percentage of patients aged seventy-five and over between the two annual periods, the difference in the mortality figures becomes considerably less impressive. On statistical analysis, this apparent improvement in survival rate proves to be not of definite statistical value.

In Table IV we have divided our patients into two groups, based simply upon the relative degree of activity of the patient prior to the injury. Ninety-five of our patients were considered to be active, self-sufficient persons prior to their injury, and in this group the gross mortality rate was 19 per cent. Fifty-one of our patients were considered to be complete or semi-invalids prior to their hip fractures. Of these, nearly half failed to survive their injuries. There is of course an appreciable difference in the average age between these two groups; however, statistical analysis of the factors involved illustrates that there is a definite significance in the degree of invalidism prior to the injury, notwithstanding the factor of age alone.

Table V again divides our patients into two groups, 115 patients admitted on the day of injury, and thirty-one patients admitted to the hospital later than the day of injury. A considerable difference in the mortality rates of

these two groups is apparent. However, it cannot be definitely demonstrated that the delay *per se* was an actual factor in the increased mortality rate. Many of these patients who were neglected prior to hospitalization were persons who had never had any real medical attention previously, and on the average their medical status prior to injury was considerably poorer than that of the average patient. Therefore it cannot be concluded from our series of patients that delay in admission is necessarily a contributing factor toward increased mortality, although the same factors which lead to delay in admission may very well have some bearing on the patient's general medical status.

TABLE V
MORTALITY VERSUS DELAY IN ADMISSION

	No. of Patients	Died	Mortality Rate (%)
Admitted on day of injury	115	29	25
Admitted later than day of injury	31	13	42

Table VI lists the various important medical disorders present in our series of patients at the time of admission which might well be considered to be of importance in prognosis in individual cases. In reviewing this list of figures it is again important to bear in mind the fact that the average age of the patients who lived was about ten years less than the average age of the patients who died, so that a higher figure for any one of these disorders in the column of patients who died is not of any definite prognostic significance unless it is at least double the percentage listed in the column of patients who lived. For instance, it may be seen that nearly all the patients who died suffered from significant cardiovascular disease prior to their injury. However, the prognostic import of this is considerably diminished by the fact that two-thirds of the patients who lived also had similar significant cardiovascular disease. Again, hypertension was present in a slightly higher proportion of the patients who died, but in applying this to the prognosis in an individual case, the very slight difference in these figures renders them of no significant value. Decompensated congestive heart failure was present in approximately one-quarter of the patients who expired, and was very frequently the most important single cause of death; on the other hand, cardiac decompensation occurred in only 4 per cent of the patients who survived, so that this admission disorder must be considered one of considerable prognostic significance. Similarly, obvious malnutrition was present in about a quarter of the patients who later died; among the patients who lived, malnutrition was found in less than 10 per cent. It is interesting that the percentages of patients who had had previous cerebral vascular accidents, patients who had diabetes mellitus and patients who were markedly obese did not appear to affect the mortality figures significantly. Severe anemia, severe parkinsonism, psychosis and a few other less frequently found disorders appeared to be of some prognostic value.

TABLE VI
MORTALITY VERSUS ADMISSION DISORDERS

Disorders	Patients Who Lived (%)	Patients Who Died (%)
Cardiovascular disease	67	93
Heart failure, compensated	62	60
Hypertension	34	41
Disabling arteriosclerosis	29	55
Heart failure, decompensated	4	24
Previous stroke	14	12
Diabetes	11	10
Malnutrition	8	26
Infection of urinary tract	12	24
Psychosis	10	21
Parkinsonism, severe	0	5
Blindness	2	10
Other fractures	3	7
Obesity	18	7
Bronchiectasis	1	0
Severe anemia	3	10
None	10	0

Table VII has been included to show the relative lack of statistical importance of some of the preoperative physical findings which are frequently considered to be an essential part of a patient's record from a general medical point of view. Hypertension, rapid pulse, cardiac enlargement and cardiac murmurs were present in such a large percentage of all patients, both in the group who lived and in the group who died, that certainly none of these factors taken

by themselves could be considered as significantly contributory to mortality. Again, we have analyzed the electrocardiographic findings in both groups of patients in considerable detail to determine if possible the actual importance of this procedure in attempts to estimate the risk involved in the individual patient. It will be seen from this chart that over half of the patients in each group had electrocardiographic abnormalities and that the difference in these figures, considering the difference in ages of the two groups, is not of real significance. The presence of pulmonary rales on the other hand, and significant cardiac arrhythmias, would appear to be of some very definite prognostic value. The figures listed for arrhythmias do not include benign abnormalities such as premature beats, etc.

TABLE VII
PREOPERATIVE CLINICAL FINDINGS

	Patients Who Lived (%)	Patients Who Died (%)
Blood pressure over 160/90	41	55
Pulse over 90	51	64
Heart enlarged	38	48
Murmurs	28	43
Rales	12	29
Arrhythmias	14	24
Abnormal electrocardiogram	52	69

In Table VIII we have listed the abnormal laboratory findings noted, both pre- and postoperatively, again divided into the group who survived and the other group who died. On the basis of these figures it is a little difficult to attach any very direct significance to many of these laboratory abnormalities. Anemia, leukocytosis, glycosuria and elevated sedimentation rate were found in both groups rather frequently. Gross albuminuria and elevation of the blood urea nitrogen, on the other hand, would appear to be of some possible significance. Postoperatively it is again seen that albuminuria and azotemia occur much more commonly in the group who failed to survive. A persistent elevation in the percentage of granulocytes on the differential smear was also a great deal more common in the group of patients who were to die. Most of the other abnormalities were present in approximately equal degrees in both groups.

In our review of these cases we have extracted from the records a great deal of other information concerning these patients, in an attempt to determine if other significant factors affecting the mortality figures could be ascertained. In general, these further studies yielded nothing except a large group of numbers without any useful significance. For instance, we could find no appreciable difference between survival figures for different types of fractures, neck fractures, extracapsular fractures, intertrochanteric fractures, etc. The different types of fractures are, of course, of considerable importance in prognosis as far as healing is concerned, but in this group at least the survival figures did not vary appreciably from one type to another.

TABLE VIII
ABNORMAL LABORATORY FINDINGS

	Preoperatively		Postoperatively	
	Lived (%)	Died (%)	Lived (%)	Died (%)
Hemoglobin below 11.0 gm. %	24	21	22	17
White blood cell count over 10,000 per cu. mm.	39	60	24	52
Differential over 80% polymorphonuclear leukocytes	45	62	14	43
Specific gravity under 1.010	5	2	5	2
Albuminuria over ++	8	17	4	12
Sugar	9	10	2	0
White blood cell count over 20 per high power field	20	29	11	17
Blood sugar over 140	13	12	7	7
Blood urea nitrogen over 20	28	48	13	38
Sedimentation rate over 20	37	52	15	12

Table IX compares the mortality figures in different groups as classified by the medical and anesthesiology consultants in each case when asked for opinions regarding risk. The medical men divide their patients into three groups, group 3 being those who have serious

medical abnormalities, worsening or of such nature that one might expect them to worsen during or after reparative surgery. Group 2 consists of patients with significant medical abnormalities which are of a relatively static nature. Group 1 consists of patients with

TABLE IX
PREOPERATIVE EVALUATION

	Lived	Died	Mortality (%)
Medical			
Group 3.....	10	26	72
Group 2.....	86	15	15
Group 1.....	7	1	12
Anesthesia risk			
Group 4.....	47	36	43
Group 3.....	56	6	10
Group 2.....	10	0	0
Group 1.....	1	0	0

no significant abnormalities in their general physical condition. It will be seen that by far the most important of these groups is group 3, which had an appalling mortality figure of 72 per cent. The figure serves at least to illustrate the fairly good accuracy of our medical consultants' prognostic acumen. It will be noted that only one patient in medical group 1 died; this patient was in excellent general condition and did very well postoperatively but expired very suddenly with a massive pulmonary embolus.

The anesthesiologist classifies his patients somewhat differently, into four different groups. Group 1 consists of patients with no abnormality of any sort which the anesthesiologist considers to be of any prognostic importance. In our entire group of 146 patients only one patient was classified as being in this most desirable status. Group 2 consists of those patients which the anesthesiologist considers to be good operative risks in spite of the presence of some significant physical abnormalities. Group 3 and group 4 were those groups arbitrarily considered as fair operative risks and poor operative risks, respectively. Here again, the figures serve at least to demonstrate the reasonable accuracy of the anesthesiologist's opinion regarding risk. All but six of the patients who died had been classified in group 4.

Table x summarizes the highly significant preoperative data which lead one to anticipate a serious risk in individual cases. Briefly, these factors are age, previous invalidism, delayed hospital admission, congestive cardiac failure, the presence of pulmonary rales, significant

TABLE X
FACTORS INDICATING A POOR PROGNOSIS

Age over 75
Invalidism
Delayed admission
Cardiac decompensation
Pulmonary rales
Malnutrition
Medical grade 3
Anesthesia grade 4

degrees of malnutrition and, in addition, the apparently fairly accurate estimates of risk by the medical and anesthesia consultants. None of the other factors studied can be considered to be of definite statistical significance in the preoperative evaluation of risk in these patients.

An obviously critical period in the treatment of these poor-risk patients with fractures of the hip is the time of surgery and anesthesia. In the course of reviewing these cases we have compiled a rather large mass of data concerning such factors as the length of time occupied by anesthesia and length of time required for surgery; the type of anesthesia administered, the preoperative medications and the supportive medications such as vasoconstrictors used during the time of surgery; the use of intravenous fluids during the surgical and immediate postoperative periods; the replacement of blood loss; and the patient's immediate reaction to the anesthesia. Again, we have derived from this effort a largely meaningless mass of insignificant statistics.

It is generally assumed that the length of time occupied by anesthesia and surgery should be minimized as much as possible in these poor-risk patients. After analyzing the periods of time required in these cases we can only conclude that a patient who can tolerate a surgical procedure is likely to tolerate it whether it requires three-quarters of an hour or two hours. In the poor-risk patients in general we have tried to avoid general anesthesia; but if we can believe our data, a patient who can tolerate general anesthesia does as well with two hours of it as he does with half an hour. Again, it

would appear that with general anesthesia the critical periods are those of induction and recovery from the anesthesia rather than the period of surgical anesthesia itself. The average actual operating time on these patients was just over one hour; the majority of these patients had open reductions with arthrotomy and exposure of the fracture rather than blind nailing.

Our anesthesia is administered by nurse anesthetists, who are under the supervision of a single anesthesiologist on whom we have come to rely a great deal and who takes a very active interest in our poor-risk patients, frequently personally supervising the entire anesthetic procedure on these patients. For the most part we have left the choice of anesthesia and preanesthetic medications entirely in his hands. The type of anesthesia used has varied considerably, with spinal being used quite commonly for the especially poor-risk patients. Various types of general anesthesia are used somewhat more frequently for the patient who is not a particularly poor risk. Particularly in the past year, we have been using local anesthesia supplemented by intravenous demerol® drip on a great many of the particularly poor-risk patients. We have not used this type of anesthesia often enough to have any statistical figures regarding its safety, but we are impressed with the generally satisfactory anesthetic course and postoperative status of these patients. We expect to use this type of anesthesia more and more in the future.

Over 95 per cent of these patients received from 500 to 1,500 cc. of banked blood during and immediately after surgery. The great majority of these received only a single unit of blood. We have sometimes heard criticism of the overuse of blood transfusion, particularly the use of a single unit of blood in a patient who might have been able to get along without transfusion at all. In this particular series of patients we do not believe that transfusion has been overused. Many of these patients exhibit a borderline type of anemia and all of them lose a fair amount of blood into the tissues from their fracture, as well as a moderate amount of blood, of course, at the time of surgery. We have believed that the fairly liberal use of blood has been a very important factor in maintaining these patients during their surgical and immediate postoperative periods. It is worth noting also that we have had a few minor transfusion reactions in this series, but no transfusion reaction in any of these patients which could be considered at all serious.

Postoperatively, we have tried to determine from this series of cases what incidents to watch for particularly as signs of impending difficulties. We have tried particularly to evaluate the status of these patients two or three hours after the time of their surgery, feeling that their status at about this time might be of some prognostic significance. Table XI shows the patients classified arbitrarily, as far as their immediate postoperative status is concerned, into groups labeled good, fair and poor. Nine patients at this stage were considered as being in poor postoperative condition; only two of these survived. Thirty patients were considered as being in fair condition postoperatively; half of these lived and half died. The great majority of the patients were considered to be in good condition immediately postoperatively; of these, however, fifteen died, so that more than one-third of the fatal cases could not have been predicted during the immediate postoperative period.

TABLE XI
POSTOPERATIVE COURSE VERSUS MORTALITY

	Immediate Postoperative Status		General Postoperative Course		Morale and Ambition	
	Lived	Died	Lived	Died	Lived	Died
Good.....	80	15	61	4	67	3
Fair.....	16	14	25	8	27	8
Poor.....	2	7	16	24	8	24

We have again classified our patients arbitrarily as good, fair and poor insofar as their general postoperative course, during the first five to ten days postsurgery, is concerned. A great many of these patients, as we have all seen, seem to tolerate their injury and their surgery remarkably well in spite of their fairly precarious condition, and in this series sixty-five were classified as having a good general postoperative course. However, four of these patients, a not insignificant percentage, succumbed after several days, in each case from a catastrophic complication such as massive pulmonary embolism, cerebral vascular acci-

dent, etc. An additional thirty-three patients were classified as having a fair general postoperative course. These patients seemed somewhat precarious part of the time and sustained various complications, but the majority of them lived. An additional group of forty patients were classified as having poor postoperative courses. They reacted poorly in the first few days after surgery; they had major complications and were in general considered as being in unsatisfactory condition. Well over half of these patients failed to survive, although sixteen did live in spite of what appeared to be rather overwhelming odds against them. This group of sixteen patients who survived in spite of poor general pre- and postoperative conditions constitutes an extremely interesting group for detailed study. These, we believe, are the patients who could not possibly have survived conservative treatment, and we are inclined to believe that these, by and large, are the patients who are saved by surgical intervention.

Our patients are again classified arbitrarily into good, fair and poor groups on the basis of our general impression of their postoperative morale and ambition. This is necessarily a rather vague and poorly defined way of classifying patients. Some of these people were in such poor general condition that anything resembling good morale and ambition was obviously impossible. On the other hand, a fair number of these people were in reasonably good physical condition but appeared to resist actively any and all efforts toward self-help. Seventy patients were classified as good in this category, and here the mortality rate was quite low. Thirty-five were classified as exhibiting fair morale and ambition, and here again the majority of these patients lived. Thirty-two patients were classified as poor; here the mortality rate was overwhelming, only eight of these patients surviving. Again, the patients who did survive in spite of very poor morale and ambition constitute an extremely interesting group of people who appear to have defied all the laws of prognosis.

Table XII lists the important, commonly observed postoperative complications, and this table warrants a great deal of scrutiny since it includes the important factors in the actual cause of mortality in virtually all the patients who did not survive. Perhaps the most important single postoperative complication is that of congestive failure. This was seen in twenty-seven cases postoperatively, and only four of these patients survived. All but three of these patients had been digitalized preoperatively, and the three who had not were rapidly digitalized as soon as the condition was detected. It has not been our policy to digitalize patients prophylactically without some quite definite indication for the medication. We believe that our experience verifies this as the proper policy.

TABLE XII
POSTOPERATIVE COMPLICATIONS

Complication	Lived	Died
Congestive failure	4	23
Dehydration	6	15
Electrolyte imbalance	2	9
Pneumonia	2	12
Shock	1	6
Asthenia	11	13
Urinary infection	8	8
Decubitus ulcers	11	8
Psychosis	8	7
Cerebral vascular accident	1	4
Cardiac infarction	0	5
Embolism	1	8
Phlebitis without embolism	2	0
Uremia	3	7
Wound infection	8	6

Twenty-one patients are listed as having exhibited dehydration postoperatively; these people exhibited moderate to fairly severe dehydration, mild cases of dehydration not being included. Eleven of these patients were so severely dehydrated as to exhibit definite electrolyte imbalance. These patients were not dehydrated because of neglect, most of them being people with cardiac or renal insufficiency in whom adequate hydration is frequently a virtual impossibility. It will be seen that dehydration severe enough to produce definite electrolyte imbalance is likely to be an unsurpassable obstacle; only two of these patients survived.

Similarly, fourteen patients are listed as having had their courses complicated by pneumonia postoperatively. We have not included patients with relatively minor patchy areas of atelectasis, or mild tracheobronchial inflammations or cases of minimal localized pneumonitis. These patients had frank pneumonia, almost always bronchopneumonia, and this again is an

obviously catastrophic complication, only two patients surviving such a complication.

Sixteen patients exhibited serious urinary tract infections postoperatively. Again, we have not included minor cases of cystitis and other relatively unimportant inflammatory reactions, but only febrile cases which constituted a definite menace to the patient. Half of these patients failed to survive. One additional infectious complication is one which again bears a great deal of scrutiny. In this series there were fourteen cases of wound infection. About half of these were quite severe, with actual production of pus and some evidence of septicemia. The other half were relatively minor wound infections, superficial and usually involving the suture material. Of the patients with major, deep, pus-producing wound infections, only two were able to survive. In the six who did not it was quite obvious that the wound infection was at least a major contributory cause of death.

TABLE XIII
SUGGESTIONS FOR POSTOPERATIVE CHANGE TO A POOR PROGNOSIS

Poor immediate postoperative status
Poor general postoperative course
Poor morale and ambition
Adverse laboratory data
Axotemia
Persistent leukocytosis
Any single serious postoperative complication, especially:
Congestive failure
Electrolyte imbalance
Pneumonia
Shock
Cerebral vascular accident
Cardiac infarction
Embolism

In considering these infectious complications one of course comes to the question of the use of prophylactic antibiotics in these poor-risk patients. It has not been our policy to use the antibiotic umbrella routinely, but we have reserved it for exceptional circumstances. Of the patients who experienced infectious complications, the overwhelming majority were patients in definitely poor general condition preoperatively. Many of these patients exhibited some degree of malnutrition, most of them had cardiac disease and about half had diabetes. We have not arrived at any definite conclusive policy as to the use of prophylactic antibiotics, but we are more or less inclined to believe that this is indicated in diabetic persons especially, and perhaps also in persons with chronic cardiorespiratory abnormalities.

Three groups of complications, including cerebral vascular accidents, myocardial infarction and pulmonary embolism, can be seen to be rather obviously devastating. Nineteen such complications occurred, and only two of these patients survived. There is no question but that there must have been at least a few cases of undetected minor pulmonary emboli and so-called little strokes which have not been included in these figures, so that our statistics here certainly are somewhat defective. Again, we have only two recorded cases of phlebitis without embolism. Certainly in a series this large of aged patients the incidence of postoperative phlebitis must be considerably higher than this. This is a complication for which we are always looking, and certainly our statistics here again must be inaccurate.

Uremia was seen ten times postoperatively, and only three of these patients survived. So-called chronic shock, exhibited over a fairly prolonged period postoperatively, was seen seven times, and again nearly all these patients failed to survive. General asthenia, decubitus ulcers and frank psychosis was also seen quite frequently; in contrast with most of these other major complications, about half of the patients in each of these groups managed to survive in spite of the complications. Only two additional causes of death, not included in this present list of postoperative complications, were recorded. One patient had a severe persistent postoperative ileus with a fatal outcome. Another patient had a rather massive atelectasis and died.

To summarize the postoperative incidents which can be expected to lead to an increased risk of fatal outcome, we can include the items listed in Table XIII. A poor immediate postoperative status, a poor general postoperative course during the first few days, and especially evidence of poor morale and ambition are frequently the forerunners of a fatal outcome. Adverse laboratory data, especially azotemia or persistent leukocytosis, constitute a less definite and apparently less important group. Any single serious postoperative complication of course exposes the patient to extremely serious risk. The complications especially in-

volved were those of congestive failure, electrolyte imbalance, pneumonia, shock and the catastrophic circulatory complications of cerebral or cardiac infarction, or pulmonary embolism. This last group in particular is of considerable importance, since these three complications not uncommonly cause death in patients who previously had been considered fairly good risks.

We believe that we have learned a good bit in conducting this study, and expect to continue it from year to year in the future, in the general interests of improved patient care. We might also hope that larger, more completely integrated groups might be stimulated to carry out similar studies.

Our original motive in conducting this study was that of attempting to find some means of improving our over-all gross mortality figures, and especially our surgical mortality figures. In the entire series of 146 patients, 138 were operated upon, only eight cases being treated conservatively. Each of these eight cases was considered to be beyond possible consideration for surgery. Of the eight patients denied surgery, only one patient survived. In reviewing our cases it appears rather obvious to us that a fair number of patients were operated upon who were not in appreciably better condition than were those in the small group of eight patients denied surgery. In general, these constitute the group classified by the medical consultants into group 3, with a mortality rate of 72 per cent. The important thing about this group of patients is the fact that ten managed to survive. We cannot help feeling that a few of the patients who were denied surgery might have managed to live had internal fixation been performed. Our general trend over this four-year period has been to operate upon a larger and larger percentage of patients, and in the last year included in this series, which included the largest number of patients, every patient was treated surgically. Certainly by so doing, we have kept our surgical mortality rate high, but we are reasonably certain that at the same time we have kept our overall mortality rate down to a minimum. We are more and more convinced that the only possible means of treating these patients with any hope of survival is that of surgical fixation of the fracture. To deny surgery, except in the case of the obviously moribund patient, is to deny a patient whatever small chance of survival he may have.

We have no means of predicting precisely who will live and who will die, although we can apparently select a small group in which the survival rate will be only 25 per cent. Should we, on this basis, deny surgery to the medical group 3 patient? Certainly by so doing we could publish a greatly improved surgical mortality figure. Equally certainly, we would be denying this group of patients their admittedly slim chance of survival.

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DISCUSSION OF PAPERS BY DRS. MAHONEY, MULHOLLAND, JAHR AND DARLING; AND RENO AND BURLINGTON

Charles S. Neer, II (New York, N. Y.): I had the pleasure of reading and studying the paper by Dr. Jahr and his co-authors, comparing it with some of our results at the Presbyterian Hospital. Theirs is an important, unbiased report, emphasizing the value of the replacement prosthesis for fresh fractures. We are in agreement with practically everything he has said, with a few exceptions which I would like to mention.

First, it is implied in the conclusions that one basis for deciding to use a prosthesis rather than internal fixation is the nature of the fracture, the direction of the fracture line and the level. Actually there is no accurate means at the present time to determine which fracture is going to do badly. In a current incomplete study in our hospital of the first sixty-eight displaced fractures of the femoral neck that had been treated by internal fixation, thirty-four were quite satisfactory after two years, with no significant complication. Therefore it would seem improper to use a prosthesis in a patient with a reasonable life expectancy, provided he or she was physically active. To put it another way, if the expectancy is not much greater than the healing time of the fracture, or if the activities were impaired sufficiently so that he or she would

not be expected to do much walking in any case, replacement of course is a great adjunct.

Second, prosthetic replacement in elderly patients with fresh fractures presents problems different from those of ordinary replacement. We have a desire to get these patients out of bed early and to start early ambulation. Furthermore, the acetabulum is normal and we do not need to expose it. Therefore it is undesirable to have to detach the abductor tendons as is done in the Gibson approach. The approach, either in front or back, which leaves the abductor tendons intact is more desirable. We have avoided the Gibson exposure and have been able to get the patients out of bed usually within forty-eight hours.

Replacement prosthesis is not a panacea. The mortality encountered in this study was 17 per cent. Furthermore, insufficient time has elapsed since 1950 for determining the durability of these appliances. Replacement prosthesis is a method, as the authors have shown so well, which is of great value in treating the patient rather than treating the fracture. The fact remains that bone union with a viable femoral head is the preferable goal to aim for when the general status of the patient makes it sensible to try for it.

JAMES KEANE STACK (Chicago, Ill.): Secretaries, as a group, like to be asked to discuss papers because it reminds them that they, too, are doctors. So, when Dr. Mahoney asked me if I would discuss his paper, I was delighted to do so.

All over the country, in this day, people are sitting back and taking a long, hard look at this entire prosthetic business. Whether the prosthetic devices will be discarded completely, I do not know. Our experience goes back to 1948, and we have some cases that are a pleasure to me. We have others that are indefinite, and still others that I wish I had never seen. I am sure that your experience is about the same.

I am also sure that if and when we do discard the metallic or plastic prosthetic device, the last group of people that will be kept for this method of treatment will be the group that Dr. Mahoney and his confreres have discussed.

He mentioned that one of the groups they had trouble with was the chronic alcoholic. I have often had trouble telling just what a chronic alcoholic is.

ROBERT H. KENNEDY (New York, N. Y.): I had the opportunity to go over Drs. Reno and Burlington's paper before it was presented. It shows the result of a tremendous amount of meticulous work and was of great interest to me.

If the producing accident occurred while the patient was active enough to be walking about, I believe he will never be in better condition for operation than at the first moment the operating room can be gotten ready. If he was chairbound or bedridden at the time of the accident, the time that is taken for preoperative preparation may make less difference. We seem to be stymied often by getting so-called medical clearance. Of how much definite value is medical clearance to us?

The authors of the paper seem to believe that their medical consultants have been of real value to them as they show in some of their statistics. However, the various factors which were mentioned in the physician's and laboratory examinations which they found might be of some importance statistically, at least regarding later mortality, all seem to me to be those in the range of discovery and evaluation by the average surgeon.

About a year ago, when I was asked to plan a panel discussion on the treatment of injury in the aged, I thought that one portion might well be allotted to an internist who could tell the group of surgeons just what he had to offer and what benefit the surgeon might expect from asking for and getting medical clearance.

I called medical men, or asked surgeons for recommendations, in five of our large hospitals in New York City. I could not get anyone in the medical field to take that assignment, to tell us what he had to offer. Surgeons in two of the hospitals told me they had given up asking for medical clearance because it might cause delay and, to them, did not seem to mean anything in the ultimate results for the patients when this medical clearance was obtained. This seems to be a defeatist attitude. Of course it may be unfair to your internist confrere, but I wonder whether our request in these cases for medical clearance might not be just a defense mechanism on our part or evidence of inertia toward thinking through the importance of the abnormalities which are obvious to us in relation to the anesthesia and timing of operation.

In many instances, it seems to me, the worse the condition, the more promptly the patient should be offered the possible benefits of operation.

I want to congratulate the authors on their article and on the important results brought out.

PRESTON WADE (New York, N. Y.): I, too, had an opportunity to read Drs. Reno and Burlington's paper and to study it at some length. It is really a wonderful piece of work and can give you a great deal of information. Some of the things, of course, we all agree with. The mortality, so often a result of cardiac decompensation, is what we fear most. I think that is the thing we worry most about in our patients—the debilitated patient also, of course, those that are invalided before they come to us.

In the paper the authors say they did not notice that the length of operation particularly increased the mortality. We found that in our cases (up to one hour, one and a half hours, two hours) it has not seemed to make any difference. However, in

those cases in which the operator had gotten into trouble and had to go on an unusually long time, the mortality rose sharply. We believe that is something to consider.

Our mortality rate for the first six months of this year was three cases of fifty, or 6 per cent. We believed we were making progress. We then lost five patients pretty promptly, and our mortality rate has now risen to 10 per cent. By the end of the year it might be higher than that.

We think, also, that the early operation is a good aid in decreasing mortality, but we do not think it is necessary to operate the minute the patient comes into the accident room. Certainly I think that early operation on the old, debilitated patient is extremely important. I think this is a valuable presentation and that it will take its place with the papers that are often read and referred to.

In reference to the first paper, I would like to say something about the fact that we have done a few primary replacements for selected cases of intracapsular fractures. We have recently become very much interested in the posterior approach as described, and like it better than the anterior approach. We believe that it is not necessary to put on the plaster boot, which we found causes a great deal of difficulty.

FRANK E. STINCHFIELD (New York, N. Y.): First of all, I would like to congratulate the authors of these papers. Both were extremely well presented and those of us who have written a statistical paper know the long hours that went into their preparation.

The decision as to whether or not a prosthesis should be inserted is often made by a man with limited experience. This, I believe, is unfortunate as I think this operation is one of the most difficult that we perform. It is a complicated surgical procedure and also presents problems in determining whether or not surgery should be performed.

There seems to be a tidal wave of enthusiasm right now that the easiest way to fix a fracture of the neck of the femur is to insert a metal prosthesis. Dr. Mahoney and his group have shown that in the elderly it certainly has a great advantage. However, I am sure that you, as we, have found that men in their training and formative years are desirous of inserting prostheses without always limiting the indications to the elderly group, such as Dr. Mahoney advises. I think Dr. Mahoney's group is of particular interest because we all know Bellevue Hospital cares for many derelicts and I think it is commendable that he has done so well.

I think it is important to avoid severing the gluteus medius muscle whenever possible. I have yet to see a case when the gluteus medius was severed in which there was not a gluteus limp postoperatively. In our experience, the anterior Smith-Petersen approach has served us well.

I would also like to mention the fact that we have found the use of anticoagulants postoperatively in the elderly group to be of definite aid in the prevention of thrombophlebitis.

DOCTOR HIERTON (Stockholm, Sweden): I very much enjoyed these presentations and discussions. At this moment, when these prostheses are on the point of being thrown away by many, we also reviewed our service. It was said some of the patients were nice to me, but not all of them. We have some of the figures from follow-up studies which would be of interest to bring up at this time.

During the first period of use of these adjuvants about 14 per cent were operated upon because of trauma. During the latter part 28 per cent were operated upon. A follow-up examination of the traumatic cases within time of observation from two to eight years showed that those patients operated upon late had traumatic arthritis. They did badly; they showed bad results. However, in those cases operated upon rather early, either fresh or for necrosis of the head, before any secondary changes had developed in the acetabulum, the patients did well. If we consider the patients' own estimations of their conditions, about 60 or 70 per cent claimed that they had benefited from the operation and did well.

According to the objective registration, somewhat less than 60 per cent showed satisfactory results. The rate of complications after these replacement resections is, however, high, and we feel it is justified to use the resection, reconstruction method, only in selected cases of acute fractures.

In the very elderly patient these fractures may be considered almost a pathological fracture.

CHARLES O. CAROTHERS (Cincinnati, Ohio): We certainly have heard a very complete follow-up study, and I want to add a few figures from the Cincinnati General Hospital on prosthetic replacement in fresh fractures of the hip.

Since 1951 we have treated 104 cases. They have been largely Austin-Moore prostheses in the last five years, and we have had three deep infections which have required removal of the prosthetic device. There have been four dislocations in the 104 cases, but I would like to point out especially, in reference to Dr. Mahoney's group, that our cases are all gotten up within forty-eight or seventy-two hours. They are all walked within one week, and we have added one thing to the operative procedure, namely, resection of a goodly portion of the capsule in an effort to stop the formation of heteroplastic bone, which has limited some of the motion in our cases.

In spite of the fact that we have resected the capsule in most of our cases, particularly in the last three or four years, we have had only four dislocations, two of which could be reduced by

manipulative treatment. The incision we use is a Gibson approach, but we believe that by leaving the abductor attached and just dividing the short external rotators we do not get too high an incidence of dislocation; I believe four in 104 with a history of walking these patients within a few days is not too bad.

JOSEF JAHR (closing): I would like to thank all those who commented on our paper.

Dr. Neer, I would like to add one statement. Although the average age of our patients may appear a little young, this is mainly because the patients with pathological fractures brought the average down. These were people in a younger age group than those with actual fractures.

I agree, too, with what Dr. Hierton had to say, that the people operated upon early do better than those whose operations are delayed. We mentioned thirty-five delayed cases—they did not do as well on an average as the early cases.

HENRY BURLINGTON (closing): I do not have anything to add except to thank the discussers. There is more detailed statistical information in the paper that will be published which does represent a great deal of work, but for the most part the risk statistics are not significant. All we did was to demonstrate the fact that, in our series at least, a great many of the things that are thought to be of considerable significance in survival do not appear statistically to be of any real importance.

Isolated Fractures of the Intercondylar Eminence of the Tibia

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THE isolated fracture of the intercondylar eminence of the tibia is frequently overlooked. Interest in studying this condition was stimulated by two patients who were admitted to our hospital within a period of two months presenting inability to extend the knee fully due to an unrecognized bone block. (Fig. 1.) This paper presents the clinical findings and results of treatment of forty-two fractures of the tibial spines, without associated fracture of the tibia, treated by the Fracture Service of the New York Orthopaedic-Columbia-Presbyterian Medical Center between the years 1932 and 1955.

CLINICAL FINDINGS

Age and Sex. Contrary to the usual statement that these lesions occur predominately in childhood, they were seen with equal frequency in adults (Table I), with twenty-one patients being under seventeen years of age and twenty-one patients over seventeen years of age. The youngest was seven years old and the oldest sixty years old. There were twice as many males as females.

Mechanism of Injury. Twenty patients had received a direct blow on the anterior or lateral aspect of the knee as evidenced by an abrasion or contusion. The fracture was produced by falling, sledding, being struck by an auto, or other severe trauma. A clear history of a twisting force was obtained from five patients. Often, the details of the injury could not be analyzed. (Table II.)

FIG. 1. J. H., twelve years old. Admitted six months after injury because of inability to extend the knee fully.

Interval from Injury to Treatment. The interval from injury to treatment was usually short, due to the acute symptomatology. The majority of patients were seen within twenty-four hours. (Table III.) Seven patients were seen several weeks or months after injury, at which time each was unable to extend the knee completely because of impingement of the malunited fragment.

TABLE I
AGE (FORTY-TWO CASES)

Age of Patients (yr.)	No. of Cases
1–10	11
11–20	13
21–30	6
31–40	5
41–50	3
51–60	4

TABLE II
MECHANISM (FORTY-TWO CASES)

Mechanism of Injury	No. of Cases
Direct	20
Anterior	11
Lateral	9
Indirect	5
Abduction	4
Hyperextension	1
Obscure	17

Roentgenographic Findings. In most instances the bone at the site of attachment of the anterior cruciate ligament, which is just anterior to the medial intercondylar tubercle, was avulsed including the medial tubercle. (Fig. 2.) In seventeen patients the entire intercondylar eminence was fractured. There were seventeen non-displaced lesions and twenty-five with displacement. (Table IV.)

Physical Examination. The occurrence of a rapidly accumulating hemarthrosis was a consistent finding in the recent injuries. This was associated with pain and limitation of motion. Adequate testing for ligamentous instability was accomplished in twenty-four patients and a positive "drawer sign" was elicited in only six instances (Table V.) Indeed, it became apparent that this clinical sign, which is credited with revealing an anterior cruciate disruption, was indicative rather of an associated collateral ligament tear. Concomitant medial joint tenderness was documented in approximately one-half of these injuries.

TABLE III
INTERVAL FROM INJURY TO TREATMENT

No. of Weeks	No. of Cases
Under 3	35
Over 3	7

TABLE IV
X-RAY FINDINGS (FORTY-TWO CASES)

Site	No. of Cases
Medial tubercle	25
Lateral tubercle	1
Entire eminence	17

TABLE V
DRAWER SIGN (TWENTY-FOUR CASES)

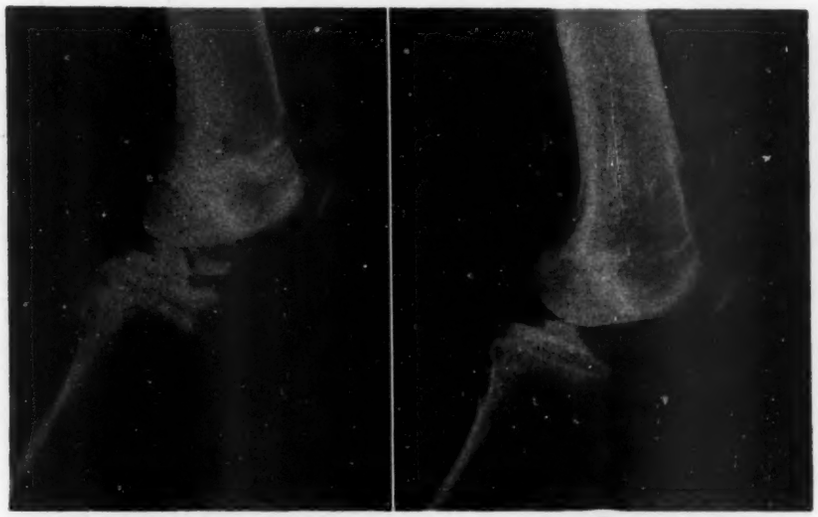
Results	No. of Cases
Positive	6
Negative	18

In the old neglected fractures, limitation of extension, joint effusion and marked quadriceps wasting were observed. (Fig. 3.)

TREATMENT

The majority of the non-displaced fractures were treated by joint aspiration and early active motion in traction, balanced suspension or on crutches. Four similar lesions were protected with plaster for from six to eight weeks. (Table VI.)

Displaced fractures required reduction. This was accomplished in twelve patients by hyperextending the knee and displacing the tibia backward after aspiration under appropriate anesthesia. The criteria for completeness of reduction was the ability to straighten the knee fully. (Fig. 4.) The knee was then im-



2A 2B

FIG. 2. B. B., eleven and a half years old. A, note avulsion at site of insertion of anterior cruciate ligament; B, postexcision X-ray film. No anteroposterior instability was noted clinically.

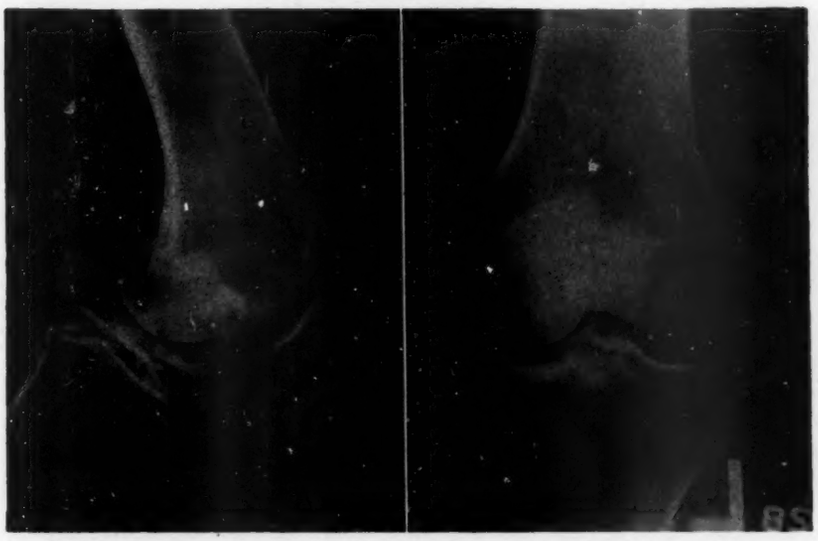


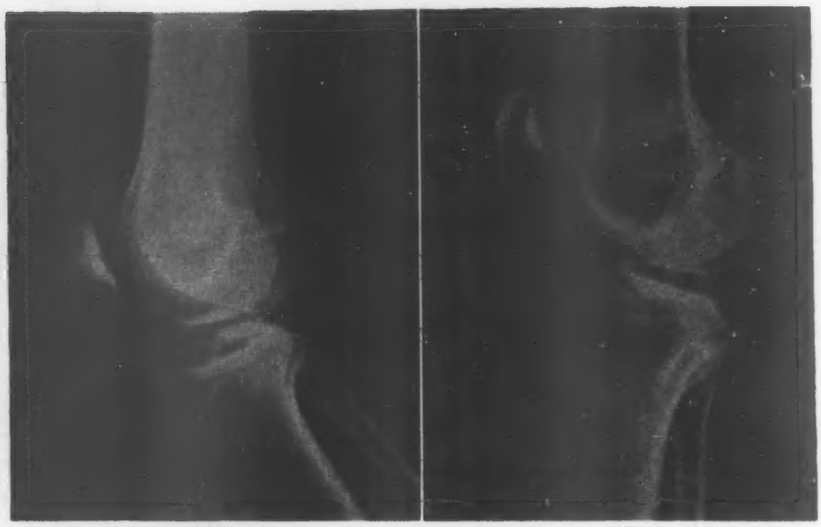
FIG. 3. M. D., twenty-two years old. Seen five months after injury with extension of knee limited to 165 degrees.

mobilized in plaster at 180 degrees for six to eight weeks. Closed reduction failed in three recent injuries and these were treated by arthrotomy for replacement and fixation by stainless steel suture. (Fig. 5.) In four late lesions, reduction of the fragment was made impractical by repair tissue and new bone. In this situation, the new bone and scar, the fragment and the anterior cruciate ligament were excised and early exercises and quadriceps drill were instituted. (Table VII.)

Two patients with old injuries refused treatment in spite of the fact that they were unable to extend the knee fully. One of these had been mistakenly diagnosed as having a dislocation of the medial meniscus and the other had been immobilized in plaster for twelve weeks without proper reduction of the fracture.

RESULTS

Thirty patients were evaluated clinically and roentgenographically for one year to fourteen years after injury. (Table VIII.) The average follow-up was 4.8 years.



4A 4B

FIG. 4. J. H., thirty-four years old. A, displaced fracture, early; B, postreduction view after extending the knee and displacing tibia backward.

FIG. 5. J. H., nine years old. Postoperative views following arthrotomy for replacement and suture of fragment.

For the purposes of this analysis, a rating of "excellent" indicates that the joint was considered normal anatomically, functionally and economically. Those rated "good" had essentially normal function but mild complaints, such as favoring the knee or weatherache. The one "poor" result was a non-displaced fracture which became displaced while under treatment. (Table IX.)

Results of Non-displaced Fractures. Excellent results were observed with both methods of treatment. However, the fragment became detached in one patient in the early motion group and this fracture remained ununited. Subsequent arthrotomy was required. This mishap made plaster protection seem judicious, at least for certain undependable patients. Three other joints treated by early motion ultimately were operated upon for excision of the medial meniscus. It was believed that these meniscus tears had been incurred at the time of fracture. This emphasized the need for considering the possibility of other associated lesions when evaluating these benign-appearing fractures.

Results of Displaced Fractures. Closed re-

duction and plaster immobilization were consistently followed by a good or excellent result. The necessity for completeness in reduction was, however, shown by the five patients seen with bone blocks following inadequate treatment elsewhere. Excision of the cruciate ligament and the bone fragment produced no detectable instability. Actually, the results seen in the three patients who had been treated by excision and early exercises were superior to those following replacement and immobilization in plaster. (Table x.)

TABLE VI
TREATMENT OF NON-DISPLACED FRACTURE
(SEVENTEEN CASES)

Method of Treatment	No. of Cases
Plaster	7
Early motion	10

TABLE VII
TREATMENT OF DISPLACED FRACTURE
(TWENTY-FIVE CASES)

Method of Treatment	No. of Cases
Plaster	16
Replacement and suture	3
Excision	4
Refused treatment	2

TABLE VIII
FOLLOW-UP (FORTY CASES)

Period of Time (yr.)	No. of Cases
1–2	5
2–4	12
4–8	10
8–14	3
Unsatisfactory follow-up	10

COMMENTS

These fractures represent an attempt at dislocation of the knee joint. Associated meniscus and collateral ligament injury is frequent. In 1907 Pringle [1] demonstrated that it was impossible to separate the anterior cruciate ligament without tearing the deep layer of the medial collateral ligament. In view of the frequent associated ligamentous damage, recent fractures of the tibial spine should be immobilized to afford time for mending of occult associated ligamentous injuries.

In contrast to the recent injuries, old fractures of the tibial spine producing bone block are best treated by excision of the fragment, callus, scar and ligament with emphasis on early quadriceps exercises. The anterior cruciate ligament is expendable provided there is good quadriceps tone and intact collateral ligaments. Although it is generally believed that the anterior cruciate ligament is essential to prevent anterior glide of the tibia on the femur, no instability was present in this plane in patients treated by excision of this ligament. Smillie [2] quotes Goodsir as suggesting that the chief function of the anterior cruciate ligament is to guide the rotation of the tibia outward as the knee joint is extended by the quadriceps. However, no weakness of extension nor increased rotation of the tibia was observed in the joints where this ligament was excised, provided the quadriceps tone was normal. It has been the practice in our clinic for many years to excise rather than repair torn anterior cruciate ligaments when encountered at

TABLE IX
RESULTS: NON-DISPLACED FRACTURE

Method of Treatment	No. of Cases		
	Excellent	Good	Poor
Early motion (8 cases)	3	4*	1
Plaster (4 cases)	3	1	0

* Three patients required meniscectomy later.

TABLE X
RESULTS: DISPLACED FRACTURE

Method of Treatment	No. of Cases		
	Excellent	Good	Poor
Plaster (12 cases)	9	3	0
Replacement (3 cases)	1	2	0
Excision (3 cases)	3	0	0

operation for removal of the medial meniscus [3,4]. This procedure has produced no measurable instability. Although dozens of operations for late repair of the anterior cruciate ligament have been described, there has been no occasion to use one of them.

CONCLUSIONS

1. Fractures of the intercondylar eminence of the tibia are often overlooked and should be suspected in patients at any age who present a rapidly accumulating hemarthrosis.

2. Concomitant lesions must be suspected in this fracture. The presence of the "drawer sign" is indicative of collateral ligament tear or poor quadriceps tone rather than simple disruption of the anterior cruciate ligament. Aspiration of the joint and adequate anaesthesia is essential for proper evaluation of these injuries.

3. Recent fractures with displacement should be accurately reduced to prevent a bony block to extension. All recent fractures should be protected with plaster until the associated ligaments have fully recovered.

4. Old fractures that block extension of the knee are best treated by excision of the anterior cruciate ligament, the fragment and the callus, to permit early exercise for quadriceps strengthening.

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Open Versus Closed Methods in Treating Fractures of the Leg

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IN the last two years the authors have reviewed 165 fractures of the shaft of the tibia as found in the files of the Combined Fracture Service of the New York Hospital and the Hospital for Special Surgery, New York City. The healing times of these cases have been established on the basis of when the patient was successfully permitted unsupported weight bearing. This has been determined more by the feel of clinical union in the leg than by abundance of callus on x-ray, although a reasonable amount of callus has always been required.

The New York–Special Surgery series follows a previous study by one of us (R. D. C., Jr.) of 111 fractures of the tibial shaft from the files of the Valley Forge Army Hospital, Phoenixville, Pa. This group was selected from civilian type injuries rather than those due to missile wounds. Healing was judged in terms of very dense bone union by x-ray just short of, or including, remodeling of the tibia, and thus was proportionately longer in the various categories than in the New York–Special Surgery study.

The two series, totaling 276 cases, are comparable, however, in regard to the relative healing times of fractures of the leg subjected to various methods of treatment and especially in consideration of complications. They will be compared in summary tables and conclusions will be drawn from the accumulated experience of both groups after presentation of the more recent New York–Special Surgery study in detail.

FRACTURES OF THE LEG IN CHILDREN

There were thirty-eight instances of fractures of the tibia in children in the New York–Special Surgery group, which are summarized as follows:

BREAKDOWN OF AGES OF THE THIRTY-EIGHT REVIEWED

Age (yr.)	No.
0–1	0
2	8
3	4
4	0
5	3
6	3
7	7
8	1
9	3
10	5
11	2
12	2

The manner of injury is as follows: fell or jumped, twenty-five (skates six, bike two); hit by car, ten (taxi four); was-fallen on, one; dog ran between legs, one; and undetermined, one. Other interesting methods of injury besides the dog include: was pushed off fence, jumped from a swing, fell on the floor at home while prancing about, fell playing in bed with sister, another girl fell on her outstretched leg, jumping rope.

There were thirty-seven closed fractures and one open fracture. The level of fracture was the upper third, two cases; middle third, eight; junction of middle and lower thirds, nineteen; and lower third, nine. Architecture of fracture: spiral oblique, twenty-four; transverse, nine; comminuted, three; vertical linear, one; and oblique large butterfly, one. In eight cases the fibula was also fractured (automobile six, jumping two): spiral oblique, one; spiral with

FIG. 1A. Patient's age, six years. A closed fracture two days after injury. Position after closed reduction.

FIG. 1B. Displacement was not corrected. Nine weeks after injury, patient began full weight bearing without support.

butterfly fragments, one; transverse, five; and comminuted, one.

TIME UNTIL PERMITTED FULL UNSUPPORTED WEIGHT BEARING (WHICH WAS WELL TOLERATED)

Time	No.	Age (yr.)
1 mo.	1	21 mo.
5 wk.	2	2, 7
6 wk.	7	2, 2, 2, 3, 3, 7, 7
7 wk.	2	2, 3
2 mo.	8	2, 2, 5, 5, 6, 6, 10, 12
9 wk.	1	7
10 wk.	9	3, 5, 7, 8, 9, 9, 10, 11, 11
3 mo.	2	7, 10
14 wk.	2	7, 12
4 mo.	1	6
5 mo.	3	9, 10, 10

Not one patient required internal fixation or open reduction. The only complication was one instance in which wedging was needed and served the purpose well. More than three-quarters of the group were healed to unsupported weight bearing within ten weeks and, in the lower age groups, often healing which permitted such license had occurred much sooner. There were no refractures.

Conclusions. Fractures of the tibia and fibula in children are very different from such fractures in adults in the over-all ease of handling of the patient by cast methods alone and universal prompt healing. (Fig. 1.) The thicker periosteal splint in children may be the explanation. We do not have records which permit study of overgrowth in this group. The surprising infrequency of associated fractures of the fibula, which occurred in only eight patients of thirty-eight, may be due to the fact that minor greenstick fibular fractures were not observed or recorded.

FRACTURES OF THE LEG IN ADULTS (NEW YORK–SPECIAL SURGERY COMBINED FRACTURE SERVICE)

One hundred twenty-seven cases of fracture of the tibia in adults have been studied in which adequate follow-up could be obtained. They are broken down into classifications and discussion will be confined to analysis of the individual types of treatment. (Table 1.)

Method of Treatment—Screws

Screws were used in thirty-two patients in obliquities long enough for good fixation in

twenty-five closed and seven open fractures. The levels of these fractures are listed below:

Level	Closed	Open
Upper third	..	2
Middle third	1	3
Junction of middles and lower thirds	19	1
Lower third	5	1

The fibula was also fractured in twenty-six patients. The number of screws needed is shown as follows:

No. of screws	Closed	Open
4	1	0
3	5	1
2	16	6
1	3	..

In five instances screws were applied at the time of wound débridement; in two cases they were adjuvants to help fix the tibia at a secondary procedure. Primarily screws were applied at three, four, five and a half, twelve and a half, and thirty-six hours after injury. Secondarily they were used at two weeks and eight weeks after injury.

Bone chips were also applied in seven cases and did not seem to promote quicker healing. The average healing time in patients in whom screws had been used without bone grafts was 4.1 months, which was hardly different from the average healing time of 4.2 months when bone chips had been used around the fracture site. Closed fractures had a slightly better average of four months in healing than open fractures (4.3 months). The healing time in cases without an associated fracture of the fibula averaged 4.5 months, which was not significantly better than in the cases with the fibular fracture. In fact, the one instance of non-union after screw fixation was in the former group.

Complications of screw fixation included, in the twenty-five closed fractures, one delayed union to one year which was thought to be due to poor mechanics where the screws were placed at right angles to the fracture site instead of at right angles to the long axis of the tibial shaft. (Fig. 2.) Also there was one non-union after infection following open reduction and screw fixation of a closed fracture. There was one infection among the seven cases of open fractures treated by screw fixation which fortunately healed in six months. Thus there was an over-all instance of non-union in the thirty-two cases treated by screw fixation of one case, representing 3.1 per cent occurrence.

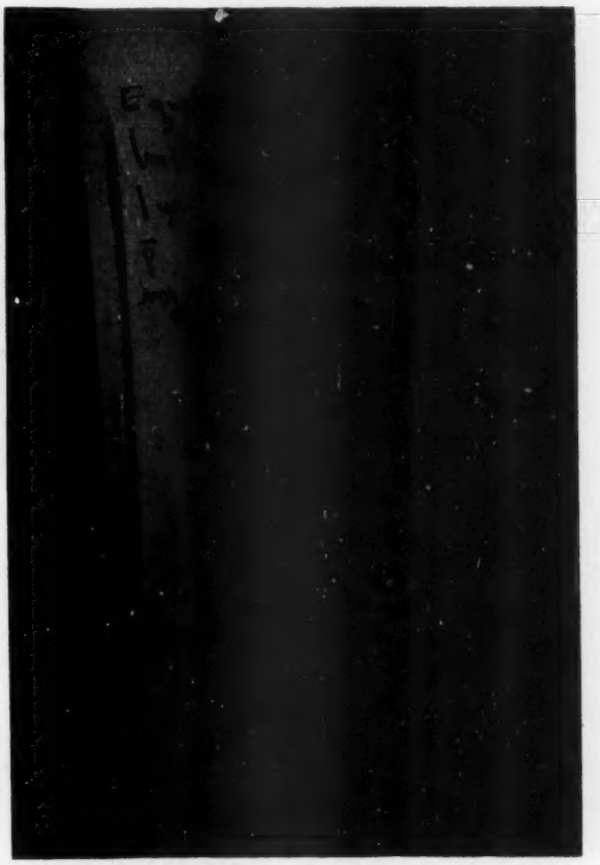
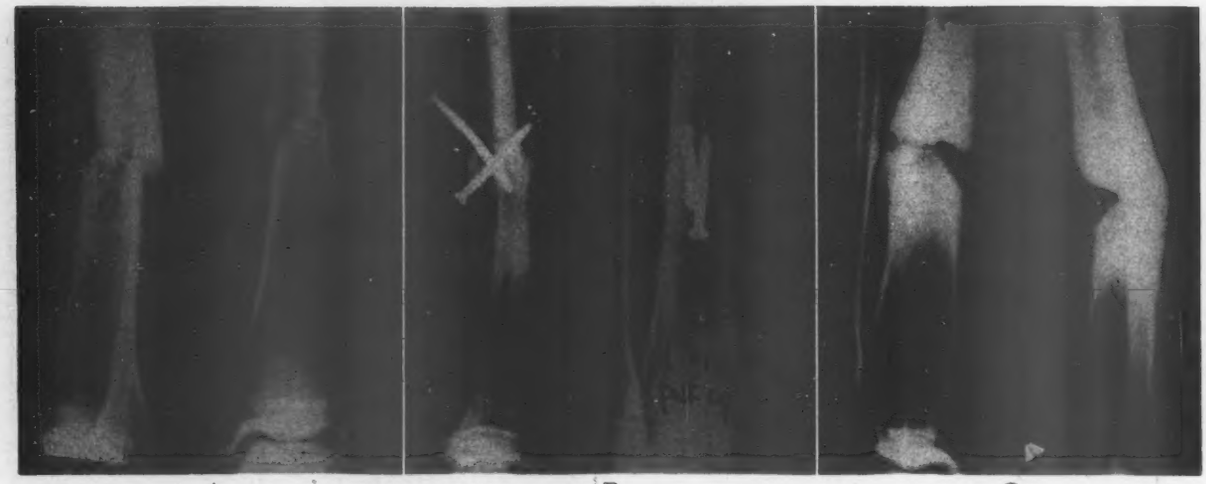


FIG. 1C. Equal leg lengths at one year after injury, comparing injured tibia with normal tibia.

Conclusions. The use of screws in oblique spiral fractures of the tibia has been proved a reasonable procedure and one well tolerated in both closed and open cases. Minimal subperiosteal dissection is required. Sharp bone fragments, which might otherwise penetrate the skin in spite of traction or cast, are held by this internal metal suture, and two screws are always preferred to one. (Fig. 3.) Dependence for fixation of fragments is primarily on the cast; the patient should not be allowed up and around on crutches postoperatively until a tight, light, long-leg plaster has been applied with the knee in some flexion. We heartily



2A 2B 2C

FIG. 2A. Original views of a closed fracture.

FIG. 2B. One month postoperatively. This is an example of the misapplication of the use of screws in a fracture with an obliquity too short for adequate screw fixation.

FIG. 2C. Evidence of delayed union at nine months after injury. A further complication was a low grade operative infection in this patient who might well have been handled by closed methods.

TABLE 1

NEW YORK HOSPITAL–SPECIAL SURGERY HOSPITAL SERIES OF ADULTS

Method Used	No.	Closed	Complications	Non-unions	%	Open	Complications	Non-unions	%	Total Non-unions	%
Screws.....	32	25	2, 1 delayed union by poor mechanics; 1 non-union with infection	1	4	7	1 infection healed in 6 mo.	0	0	1	3
Plates.....	21	11	2, 1 delayed union in transverse fracture; 1 non-union with infection	1	9	10	7 all non-unions including 3 infections (with 1 amputation)	7	70	8	38
Plates*.....	18	11	2, 1 delayed union in transverse fracture; 1 non-union with infection	1	9	7	4 all non-unions without infection	4	57	5	27
Nails.....	19	15	2, 1 death, embolism; 1 angulation failure	0	0	4	None	0	0	0	0
Bands.....	4	4	1 non-union without infection	1	25	0		0	0	1	25
Traction....	17	8	1 non-union without infection	1	12.5	9	1 infection healed in 6 mo.	0	0	1	5.9
Casts.....	34	21	None	0	0	13	1 non-union with infection; severe soft tissue injury	1	7.6	1	2.9

* Excluding three cases of open fractures plated elsewhere and admitted to New York Hospital with infection which eventually were classified as non-union.

3A 3B

FIG. 3A. Original x-rays of an open fracture.

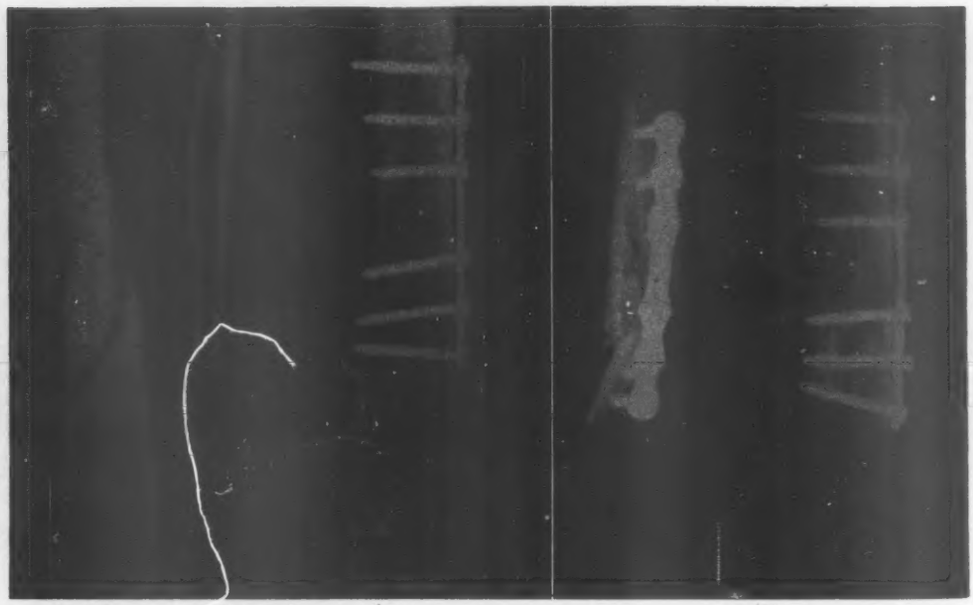
FIG. 3B. Good result from the primary use of screws which prevented wound breakdown from migration of sharp fragments in the middle third of the tibia where control by traction is especially difficult. Note the absence of peripheral callus at five months when the patient was taking full weight bearing without support.

4A 4B

FIG. 4A. Original x-rays of closed fractures. The tibial spiral obliquities are not damaged by cracks at their bases. Since the fibula was also unstable, primary internal screw fixation for the tibia was the treatment of choice to facilitate care and prevent mechanical complications.

FIG. 4B. Patient allowed full unsupported weight bearing at four months after two screw fixation.

endorse the principle of fixation transverse to the long axis of the tibial shaft rather than at right angles to the obliquity of the fracture to permit better longitudinal compression effect on the fracture [1]. It is also better mechanics to use a drill point for the near cortex which is just the same size as the screw and one smaller than the screw for the far cortex. The architecture of the fracture always determines where the screws must be placed, but screws placed from the medial approach are easier to remove later through small stab wounds. (Fig. 4.)



5A 5B

FIG. 5A. A closed tibial shaft fracture operated on the day of injury with plate and screw fixation to the lateral cortex. Mechanically, this gave excellent initial support as seen three weeks postoperatively.

FIG. 5B. Ten months later, without infection, there was angulation and non-union in spite of adequate protection of the leg.

Method of Treatment—Plates

Plates were used in twenty-one patients. Eleven closed and ten open fractures were plated. These were used in the following architectural types of fractures:

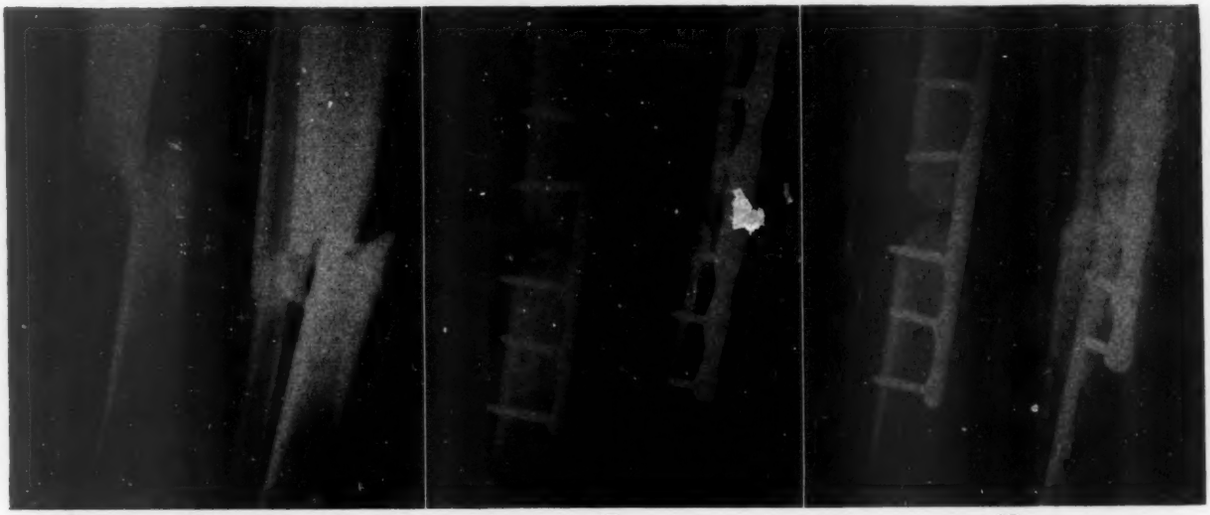
Architecture	Closed	Open
Spiral oblique	3	4
Large butterfly	3	
Transverse	1	2
Segmental	2	
Comminuted	2	4

The levels of these fractures are listed as follows:

Level	Closed	Open
Upper third	1	1
Middle third	..	5
Segmental	1	..
Junction of middle and lower thirds	9	4

The fibula was also fractured in all twenty-one cases treated with tibial plates. Three of the cases healing promptly had also received autogenous grafts at the time of plating. The average healing time of the twelve cases in which union occurred was 4.6 months for the nine closed and three open cases, with no significant improvement by the use of grafts.

Complications were frequent. In the twenty-one platings there were eight non-unions, four with infections, and one with delayed union. There were no infections in the cases treated primarily on the Combined Fracture Service at New York Hospital; all patients with infection after plating were admitted with the infection already present as a complication. Four of the patients with non-union without infection, however, were treated primarily at New York Hospital. In the one instance of delayed union which occurred in a closed case it was thought that the plate helped cause the non-union by holding the bone ends apart after absorption of the fracture site had occurred. One infection occurred after plating of a closed fracture and was followed by non-union. Of the seven non-unions occurring in platings of open fractures, one resulted in amputation. There were three infections in this group which probably were the cause of the non-unions. One had followed primary plating of an open fracture and two of



6A 6B 6C

FIG. 6A. Original views of open fractures. Tibial plating was carried out three hours after injury.

FIG. 6B. Absorption at the fracture site evident at two months, without infection. The plate and screws are now holding this transverse tibial fracture apart.

FIG. 6C. Failure of union still evident at six months after plating.

delayed early plating of open fractures at one week and four weeks after injury, respectively. In three cases of infection the plate had been put medially where it may have contributed to wound breakdown. In the four cases of non-union without infection one was oblique (Fig. 5), one transverse (Fig. 6), both showed absorption at the fracture site, which separation the plate maintained. The other two were comminuted. In all cases of non-union without infection the level of the fracture was at the junction of the lower and middle thirds including fracture of the fibula at the same level. New York Hospital Service has to accept responsibility, in spite of the absence of infections, for four non-unions and one delayed union in a total of sixteen platings. The following helps to define the responsibility for failure in the use of plates:

	Closed	Open	Total
No. of cases of infection in all platings	1	3	4
No. of cases of non-union in all platings	1	7	8
No. of New York Hospital cases with infection	0	0	0
No. of New York Hospital cases of non-union	0	4	4

In two cases not listed as complications the plate had to be removed later because of irritation and absorption around the screws.

Conclusions. The very high instance of 38.9 per cent non-union after tibial plating in twenty-one patients is not encouraging for continuation of this method of treatment. As shown also in the excellent review by Urist [4], it is presumed that, even without the hazard of infection from use of a massive foreign body on a relatively avascular bone in the presence of contamination, there is often more than permissible insult to the vascularity of the fragments in the operative manipulation and subperiosteal stripping required for application of the plate and screws. Urist has already described the 2 mm. zone of necrosis of bone wherever adjacent to metal. It seems unreasonable to use an internal fixation device which prevents dynamic coaptation of the fragments after initial bone absorption at the fracture site. In our opinion plating should be the last and not the first method of treatment considered; rarely, then, is it required. (Fig. 7.)

Method of Treatment—Nails

Nails were used in nineteen patients, fifteen closed and four open fractures. In sixteen cases Lottes' nails were employed, in two instances two nested U nails were used, and in one case

FIG. 7. Successful use of tibial plating in a closed comminuted fracture not mechanically suitable for the use of screws alone. The leg healed and allowed full weight bearing without infection in three months.

two Rush nails were used. The level of the fracture is shown as follows: junction of upper and middle thirds, three; middle third, seven; segmental, five; and junction of lower and middle thirds, four. In all cases the fibula was also fractured.

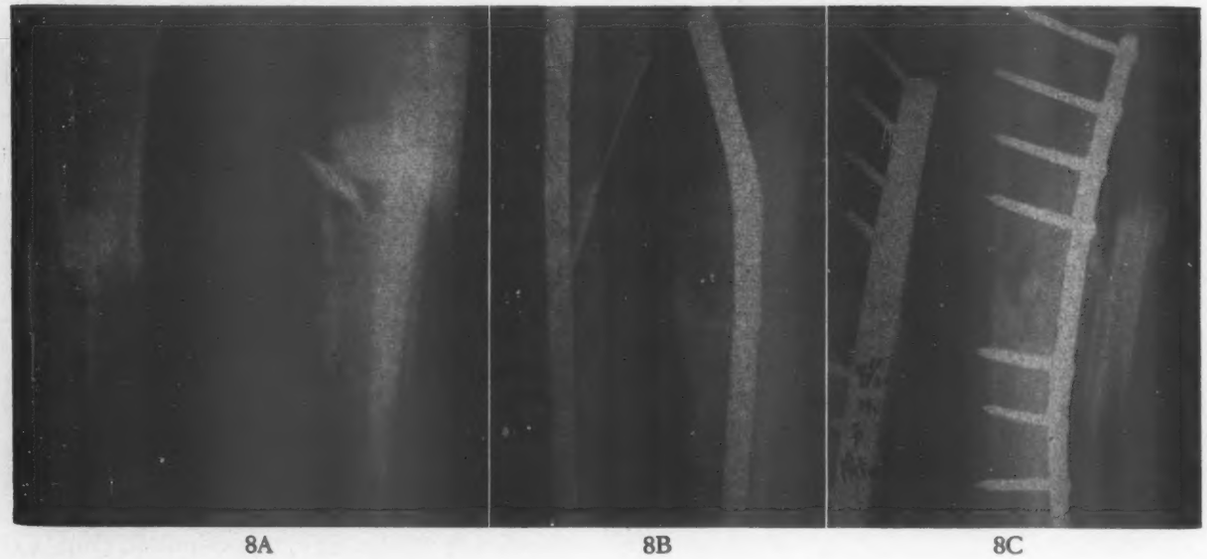
The architecture of the tibial fractures in which nails were used was divided as follows: spiral oblique, four; large butterfly, three; transverse, four; segmental, five; and comminuted, three.

The open fractures were nailed primarily with an average healing time of 4.1 months; closed fractures averaged 5.3 months in healing to unsupported weight bearing. In the five cases in which grafts were used the average healing time was 3.5 months.

The closed fractures were nailed in the following time interval after injury: one week, three; two weeks, seven; three weeks, one; four weeks, one; eight months, one; and nine months, two.

Blind nailings were attempted eight times and were successful in four instances. Complications included one death from pulmonary embolism occurring within the first month after nailing. Also there was one problem of serious angulation at the fracture site which necessitated removal of the nail and substitution of internal fixation by means of plate and screws. (Fig. 8.) In the light of hindsight, this problem could have been anticipated by a better study of the architecture of the fracture.

Conclusions. Unstable segmental fractures of the tibia are particularly benefited by intramedullary nailing. The Lottes nail securely holds tibial fragments in which the shafts con-



8A 8B 8C

FIG. 8A. Original views of open fractures.

FIG. 8B. Inadequate fixation by intramedullary nailing because of lack of sufficient tubular support in the proximal fragment. This nailing was done eleven days after injury because of lack of success in controlling fragments by closed methods.

FIG. 8C. Four and one-half months after plating which was done one week after the nailing, eighteen days after injury. By this time, the patient was able to bear full weight on the leg which felt solid clinically.

9A 9B 9C

FIG. 9A. Original views of closed fractures, segmental in the tibia.

FIG. 9B. Lateral views in the operating room ten days after injury showing the need for circumferential support at the upper tibial fracture. Angulation was corrected by a Parham band. This patient required internal fixation because of the pull of the patella tendon opening up the upper tibial fracture; also the segmental tibial shaft fractures are usually much better managed by intramedullary nailing.

FIG. 9C. Two years later, well healed. This patient had been taking full unsupported weight bearing since four and one-half months postoperatively. He refused to have the Parham band removed.

tain enough intact tubular isthmus to prevent angulation at either end. If there is comminution at either end of the middle third of the peripheral fragment, angulation may occur in spite of plaster casts. (Fig. 9.) Blind nailings are difficult in segmental fracture if there is much displacement because of the lack of control of the middle fragment. Success in blind Lottes' nailings is often achieved in single tibial fractures if one remembers that the nail is more easily engaged by the distal fragment if the latter is maintained slightly posteriorly displaced in the upper half of the tibia and slightly anteriorly if the fracture is in the lower half. Because the intramedullary canal is so much wider than the nail in the upper and especially in the lower third of the tibia, in which latter area the nail has no transcortical securement, its use is inadvisable for fractures in these peripheral locations. (Fig. 10.) Blind nailing of closed fractures of the middle third offers the intriguing double advantages of good internal fixation without the necessity of opening the fracture site and thus further interfering with blood supply to the fragments. This method requires considerable operative experience in appyling the principles already described by Hill, Key and Lottes [3] and should not be undertaken without proper equipment and ideal circumstances. If improperly applied it is easy for the nail to shatter the tibia, to become stuck or to damage adjacent soft tissues badly. In our series the one postoperative death, thromboembolic in origin, might have been the result of the nailing. In the other cases there were no non-unions.

Method of Treatment—Bands

The use of Parham bands in fractures of the tibial shaft was observed in four instances, all in closed fractures, one spiral oblique and three with large butterfly fragments. Three bands

10A 10B

FIG. 10A. Because of contamination of the fracture site by an open wound, nailing was delayed. After benign wound healing, Lottes nailing was carried out on the twenty-second day after injury.

FIG. 10B. Six months after intramedullary nailing and autogenous iliac grafting. This fracture in the middle third of the tibia was ideal for treatment by intramedullary nailing. The patient began full unsupported weight bearing at three months after injury.

were used on two occasions, two bands once, and one band once. In three patients the tibial fracture was at the junction of the lower and middle thirds, and the one in the middle third. In all patients the fibula was also fractured. Healing to unsupported weight bearing occurred at three months in two patients and at four months in another. The bands were removed in three instances at three, four and seven months. The average healing time for the group of four tibial fractures thus treated was 3.7 months. There were three minor complications, none of which affected the good end result, and one non-union. One hematoma treated at three weeks extended down to bone but healed promptly without infection. The bands left deep grooves in the cortex of two patients but without surrounding absorption beneath the circumference at which they had originally been applied. One patient who had had the bands removed routinely at three months went on without infection to have tibial non-union. (Fig. 11.)

Conclusions. The small experience of this survey in the use of Parham bands in selected types of oblique or large butterfly fragments is not sufficient for useful analysis. Failure of union of the tibia after early removal of the bands in one case and the lack of complications in two cases in which the bands have been left *in situ* for years is of interest for further study. (Fig. 12.)

Method of Treatment—Traction

Seventeen patients were isolated with adequate follow-up, from the admittedly much

FIG. 11. Closed fracture as seen on the left, fixed by two Parham bands twenty-four hours after injury. The status three and one-half months later after removal of the bands is seen on the right. The patient was then allowed partial weight bearing but went on to non-union.

FIG. 12. Five years after open reduction: Parham band well tolerated.

larger group in which this method had been used, of initial os calcis traction on a Böhler frame with cast application later. This included eight closed and nine open fractures. The level of those patients treated by traction initially is as follows: middle third, six; junction of the lower and middle thirds, seven; and lower third, four. In all patients the fibula was also fractured.

The types of fractures according to architecture are broken down as follows: spiral oblique, four; large butterfly, three; and comminuted, ten.

One patient was kept in traction for one week, five each for two weeks, and three weeks, respectively, four for four weeks, and one for five weeks. Three of these patients required wedging after being put in a long-leg cast.

There was one patient included in this group in whom transfixation wires were maintained for eight weeks, with one through the os calcis and one through the proximal tibia incorporated into the cast.

Weight bearing in the cast was allowed as follows: not determinable, three; not at all, four; ten weeks, one; three months, four; four months, four; and six months, one. Early weight bearing was not permitted in any case because all cases were either comminuted, spiral oblique, or double oblique with a large butterfly fragment, and were unstable.

There were a number of cases in which traction was applied and abandoned as undesirable which are not included in this category, but rather are listed elsewhere under definitive treatment as follows: screws, two; plates, one; and nails, three. The complications in the patients which were treated definitively with os calcis traction and long leg cast were one infection in an open case which healed at nine months and one non-union in a closed fracture. This may have been from too much traction initially.

Conclusions. The method of treatment so well outlined by Böhler [2] of os calcis traction with the leg on a frame approximately three weeks followed by rapid ambulation in a tight long-leg cast is a good method of treatment for unstable fractures in which the bone fragments in traction can be well aligned and do not tend to penetrate the skin. (Fig. 13.) The latter possibility, however, even with the most careful supervision and the use of appropriate leather-padded pressure props, will occasionally necessitate change of treatment to open reduction. Traction was abandoned in this study six times in twenty-three patients. Os calcis traction on a Böhler frame is not adaptable to mentally disturbed patients such as psychotics, patients disoriented by head injuries or those

FIG. 13A. Comminuted closed fractures of the lower third of the leg were not satisfactorily reduced by closed methods of cast alone.

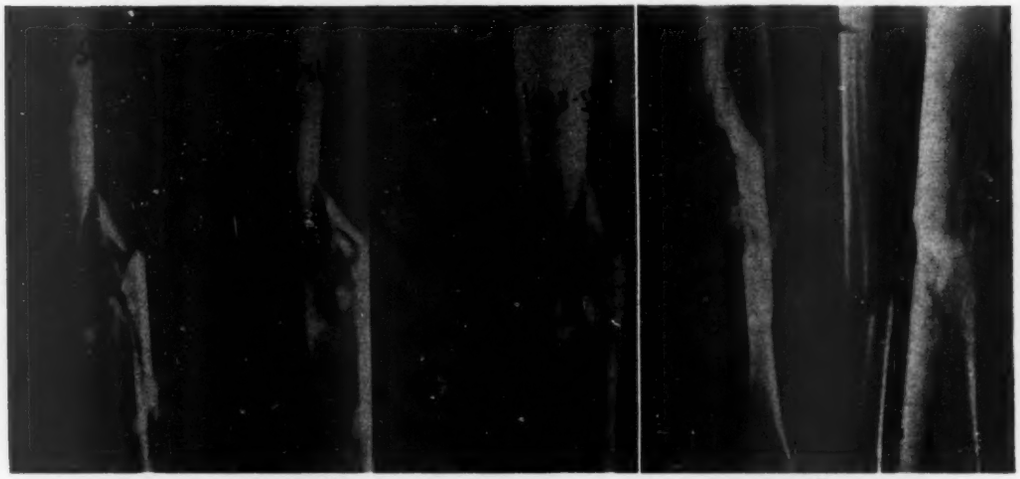
FIG. 13C. Traction had been discontinued and the patient's leg had been placed in a cast at three weeks. These x-rays show the fracture site at three months when it felt solid clinically. Full weight bearing without support was allowed at four and one-half months after injury.

FIG. 13B. This x-ray in traction, lateral view, shows correction of the position of recurvatum with eight pounds of traction through the os calcis, the leg resting on a Boehler frame. It is relatively easy to control fragments of the tibia by traction if the level of the fracture is in the lower one third of this bone and especially if there is comminution without major large, sharp fragments.

suffering from delirium tremens. Especially in considering the use of this method in alcoholics, reservations in regard to the patient's management and cooperation must seriously be considered. Os calcis traction in tibial fractures is not always easy. (Fig. 14.) Where the fracture is adaptable to other methods of treatment, they are usually preferable in terms of the time required in patient management and length of hospitalization. Occasional infections of the os calcis by the transfixation wire must be remembered although they did not develop in this group. The one instance of non-union of 5.7 per cent from overpull typifies a constant problem of supervision. Böhler recommends 7 pounds for traction in adults. The advisability of immediate full weight bearing in a skintight cast after three weeks in traction even in unstable fractures, as recommended by Böhler, has been more audacious than was permitted in our group where the average time to weight bearing in the cast was three months.

Method of Treatment—Casts Alone

Casts alone without traction or need for internal fixation were used in thirty-four patients; among these there were twenty-one closed fractures and thirteen open. The follow-



14A 14B

FIG. 14A. Lateral views of an open fracture in traction showing the difficulty of obtaining alignment and controlling the sharp fragments of the middle third of the tibia, as seen on the second, fourth, and fourteenth day after injury. Early anterior projection of the upper fragment caused the suture line to break down.

FIG. 14B. Three months after injury. The patient took full weight on this leg without a cast at six months. The fracture could have been handled much more easily by primary nailing with less chance of infection than from the reopening of the fracture site from within which occurred in traction.

ing types of architecture of fractures were so treated: spiral oblique, eleven; large butterfly, three; transverse, seven; segmental, three; and comminuted, ten.

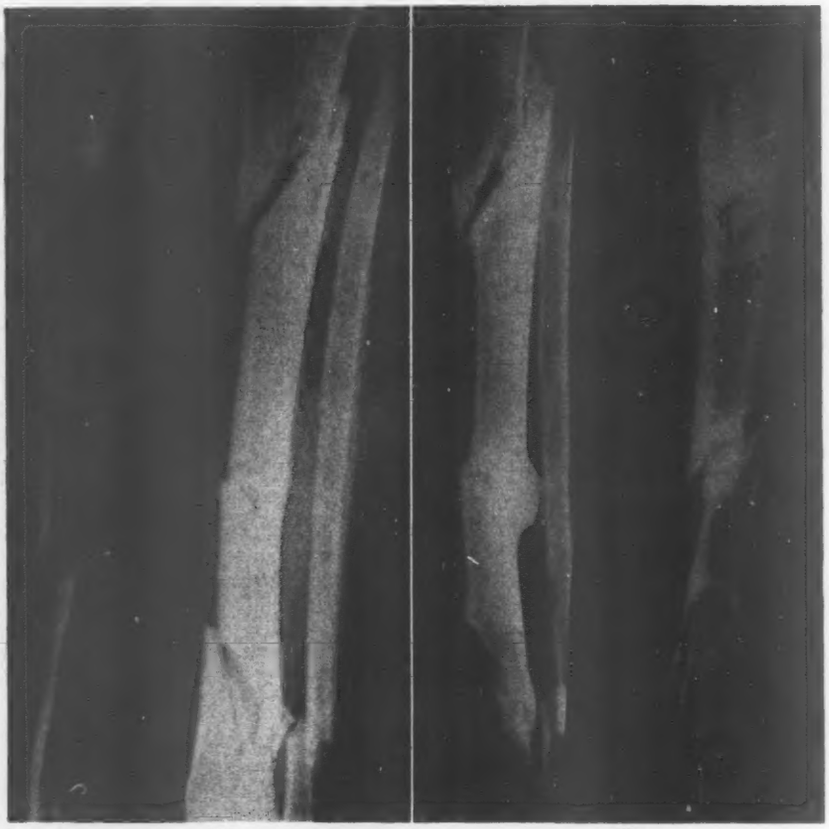
The levels of these fractures occurred as follows: upper third, five; junction of upper and middle thirds, one; middle third, six; double segmental, one; junction of middle and lower thirds, eleven; lower third, ten. The fibula was also fractured in twenty-five cases.

The healing time for the closed cases was 3.6 months; for the open fractures, six months. In the nine cases with an intact fibula healing averaged three months, compared to 4.8 months in the twenty-five cases with fibular fractures. (Fig. 15.) Wedging was required in five patients, in all of whom the fibula was fractured.

There was one complication among the closed fractures which occurred when an oblique fragment of the upper third of the shaft penetrated previously intact skin after position of reduction was lost in the cast. This, however, healed promptly after ostectomy and split-thickness skin grafting. In the open fractures there was one non-union at two years following infection.

Conclusions. The use of casts alone in a relatively large group of multiple types, stable and unstable fractures, resulted in only one non-union, an instance of 2.9 per cent, and this was following an open fracture where there

FIG. 15. A closed fracture of the tibia only is seen on the left. The other two views show moderately advanced healing at four months without loss of position. This fracture was successfully managed by cast methods only, which was possible because the fibula was intact.



16A 16B

FIG. 16A. Original views of closed fractures.

FIG. 16B. Through the use of cast methods only, healing in satisfactory position of the fragments is seen at seven months when the patient began full unsupported weight bearing. This difficult, double segmental type of fracture architecture in the tibia would have been awkwardly treated and probably delayed in healing by any of the various methods of internal fixation discussed in this paper.

had been extensive soft tissue damage. After adequate soft tissue replacement had been made, there was eventual bone union.

The relatively good results by the use of casts is a definite encouragement, in review of this series, for conservatism in the treatment of many fractures of the shafts of the tibia and fibula. Additional support for this attitude comes from the fact that other authors have reported more rapid healing time consistently in closed fractures compared to open fractures, regardless of the method of treatment. (Fig. 16.)

FRACTURES OF THE LEG IN ADULTS (VALLEY FORGE ARMY HOSPITAL)

One hundred eleven civilian type fractures of the shafts of the tibia and fibula were studied at the Valley Forge Army Hospital. Table II presents listings in the same categories as the New York–Special Surgery Fracture Service cases. As stated previously, healing times were based on more conservative criteria than in the New York cases and are proportionately longer.

Treatment of Closed Fractures. Of fifty-six closed fractures of the tibial shaft, about one-third were treated closed and had an average healing time to unsupported weight bearing of 7.7 months. There were two non-unions at one year after injury.

Approximately two-thirds were treated by open reduction and had an average healing time to unsupported weight bearing of nine months. There were two non-unions with infection; one with plate and screws, and one with screws only.

Treatment of Open Fractures. Of fifty-five open fractures of the tibial shaft, approximately half the cases were treated without internal

TABLE II

VALLEY FORGE ARMY HOSPITAL SERIES OF ADULTS (III)

Method Used	Closed	Open
Screws	19	7
Plates	14	9
Nails	4	7
Traction and transfixion	2	1
Casts only	17	31
Average Healing Time (in Months) to Unsupported Weight Bearing		
Screws (9.0)	6.7	9.7
Plates (9.6)	7.3	11.1
Nails (6.7)	6.0	7.2
Traction and transfixion (8.0)	6.5	11.0
Casts only (8.4)	6.0	9.9
Complications		
Screws (2 or 7.6%)	1 non-union at 1 yr. (from too early weight bearing at 6 wk.); 1 non-union with infection (surgery through poor soft tissues)	
Plates (4 or 17.3%)	2 non-unions, 1 with infection and 1 without infection	2 non-unions with infection
Nails (1 or 9%)		1 non-union after use of single Rush nail
Casts only (6 or 12.5%)		2 delayed unions; healed after grafts at 6 and 8 mo. and at 11 and 20 mo., respectively 4 non-unions after massive soft tissue loss over tibia at time of injury

Note: Three of the above 11 non-unions healed after reconstruction procedures at V.F.A.H.; the other patients were discharged to the V.A.

fixation, with an average healing time of 11.3 months and with four non-unions.

In the others, internal fixation was employed with healing averaging 11.5 months with 3 non-unions.

Of the seven non-unions, four patients in whom internal fixation was not used had very extensive full-thickness skin defects initially. Two of the other three had received plate and screw fixation, one of them at the time of initial débridement, and one delayed primary fixation. The other infection and non-union followed graft and screw fixation one month after drainage had ceased at seven months after injury.

Significance of Associated Fractures of the Fibula. Of the closed fractures of the tibial shaft, the healing time for one-fifth of the patients whose fibula was intact was 5.3 months compared to 8.1 months for the four-fifths who also had a fibular fracture.

Five of the open fractures reviewed had not been associated with a fibular fracture; in these the average healing time was seven months. In the others with a fibular fracture the healing time averaged ten and a half months.

Conclusions. The closed fractures treated by closed methods had a better average healing time and less complications than did closed fractures which were treated by open reduction and internal fixation. There were no non-unions by closed treatment and an incidence of 18 per cent (two of eleven) by open treatment.

The non-unions following open fractures treated without internal fixation (four of twenty-seven) were an incidence of 15 per cent which was due more to the severity of soft tissue injury than to the method of treatment.

TABLE III

COMBINED SERIES OF 238 CASES (VALLEY FORGE ARMY HOSPITAL AND THE NEW YORK–SPECIAL SURGERY HOSPITALS)

Method of Treatment	Total		Closed		Healed (mo.)		Open		Healed (mo.)		Over-all Health (mo.)	
	V.F.A.H.	N.Y.S.S.H.	V.F.A.H.	N.Y.S.S.H.	V.F.A.H.	N.Y.S.S.H.	V.F.A.H.	N.Y.S.S.H.	V.F.A.H.	N.Y.S.S.H.	V.F.A.H.	N.Y.S.S.H.
Screws	26	32	19	25	6.7	4.0	7	7	9.7	4.3	9	4.2
Plates	23	21	14	11	7.3	4.6	9	10	11.1	4.6	9.6	4.6
Nails	11	19	4	15	6.0	5.3	6	4	7.2	4.1	6.7	4.8
Parham bands	0	4	0	4	...	3.7	0	0	....	...	...	3.7
Traction-transfixion	3	17	2	8	6.5	5.5	1	9	11.0	6.5	8.0	6.0
Casts	48	34	17	21	6.0	3.6	31	13	9.9	6.0	8.4	5.1

In the open fractures with treatment by internal fixation, reason for the non-union occurrence of 11 per cent (three of twenty-six) could not be similarly explained. Suspicion is thus suggested that it was unwise to add metallic foreign body material, especially plates, to bone fragments already contaminated by open fracture.

For both closed and open fractures, the presence of an intact fibula was associated with quicker healing.

ACCUMULATED EXPERIENCE

The accumulated experience of both the New York–Special Surgery Hospitals and Valley Forge Army Hospital studies is listed in Table II in regard to the number of cases treated by the various methods and the healing times in each group, which were separated also according to whether the fractures were closed or open.

Table III is interesting in that it shows no significant difference in the result of treatment of closed and open fractures by internal fixation at New York–Special Surgery Hospitals, except in the use of nails when healing was faster in open fractures. In contrast, the open fractures of the Valley Forge Army Hospital consistently were slower in healing than the closed cases regardless of the method of treatment. In both groups, however, closed fractures treated by casts alone healed more quickly than open fractures similarly managed. There was no outstandingly successful method of internal fixation in the New York series, but nails gave much the best average healing time in the army group.

Conclusions. Eliminating consideration of complications, which will be presented and discussed next, there was little relative difference in healing times of the tibial shaft fractures according to the various methods of treatment used as compared between the two groups of 127 cases from New York–Special Surgery Hospitals and 111 cases from the Valley Forge Army Hospital. The longest healing times followed the use of plates in the Army series, whereas traction had the slowest healing in the New York study. The fastest healing observed at Valley Forge was by intramedullary nailing. At New York Hospital, bands and screw fixation had slightly more prompt healing than other methods. Properly choosing the most applicable means of treatment as deter-

TABLE IV

COMPLICATIONS IN COMBINED SERIES (VALLEY FORGE ARMY HOSPITAL AND THE NEW YORK–SPECIAL SURGERY HOSPITALS)

Method of Treatment	Total	Closed	Complications	Non-union	Open	Complications	Non-union	Total Non-union
Screws.....	58	44	1 delayed union (poor mechanics); 1 non-union without infection (weight bearing too early); 2 non-union with infection	3 (6.8%)	14	1 infection; healed at 6 mo.	0	3 (5%)
Plates.....	44	25	1 delayed union (transverse fracture); 1 non-union without infection (oblique fx); 1 non-union with infection	2 (8%)	19	4 non-unions without infection (2 transverse fractures, 1 comminuted fracture, 1 oblique spiral fracture); 5 non-unions with infection	9 (47%)	11 (25%)
Nails.....	30	19	1 death (thromboembolic); 1 angulation failure	0	11	1 non-union with single Rush nail	1 (9%)	1 (3.3% all nails) (0% Lottes' nails)
Traction-transfixion	20	8	1 non-union (overpull)	1 (12%)	12	1 infection; healed at 9 mo.	0	1 (5%)
Bands.....	4	4	1 non-union without infection	1 (25%)	0	0	0	1 (25%)
Casts.....	82	38	0	0	44	2 delayed unions; 5 non-unions with infections after extensive soft tissue loss and contamination	5 (11%)	5 (6.5%)

mined by the particular fracture problem is the art of practice, for certainly there are many ways to treat fractures of the leg and each reasonable method has its place.

The complications of the various methods of treatment of both series are considered altogether in Table IV.

There were twenty-one non-unions in the large group of 238 fractures of the leg in adults from both the civilian and Army hospitals, averaging 8.8 per cent. Ten of these were from the New York hospitals with an over-all failure rate of 7 per cent, or, if the three cases admitted from "elsewhere" with non-union and infection are not included, of 5.2 per cent. This incidence could be lowered to 4.5 per cent by discounting as inevitable one non-union resulting from severe initial soft tissue trauma and bone contamination in manure. Similarly, the Valley Forge Army Hospital over-all incidence of non-union of 9.9 per cent would be lowered to 5.5 per cent by not including four inevitable failures which were due to severe soft tissue trauma and bone comminution and contamination.

It is noted from studying the combined assortment of treatments and complications that the only method free of serious complications was simply the use of casts for closed fractures. There were no non-unions from the use of screws or traction in open fractures nor from the use of Lottes' nails in closed and open cases. Including both closed and open cases, the complications from the use of screws, nails, traction and casts were not very different. By far the highest incidence of complications resulted from the use of plates, with five non-unions without infection and six with infection, an over-all failure rate of 25 per cent. Especially shocking was the incidence of 47 per cent non-unions following the use of plates in open fractures.

Conclusions. Fractures of the leg in children can be treated well by cast methods alone, with universally good results expected.

The architectural types of tibial shaft fractures in adults, however, and the varying amounts of soft tissue damage as well as the patient's general condition help to determine the choice of treatment; certainly each method should have its place in the armamentarium of the surgeon.

If the fracture is closed and stable, there is little excuse for open reduction and internal fixation; in fact, complications might thus be incurred.

If the fracture is unstable, internal fixation or traction may be needed. Occasionally, internal fixation protects the soft tissues from penetration by sharp, unstable fragments which cannot be controlled even by traction. It is important to try to recognize this type of fracture initially and to apply internal fixation promptly before blistering and induration of the skin have occurred. It is also of prime

importance to obtain relaxed soft tissue closure over the shin bone by planning incisions which do not overlie the tibia and which are gently curved so that relaxing incisions, made at least a third of the circumference of the leg distant from the wound, will be more effective. Early replacement of full-thickness skin loss over the tibia is needed to make bone union possible.

It seems only reasonable to use the minimum of foreign body internal fixation and to rely on casts for bulk support of the leg. Thus a minimum of further dissection of bone fragments already in jeopardy of inadequate blood supply is necessary. In this regard, screws and bands are useful for oblique spiral fragments and those with large, sturdy butterfly fragments; screws have been well tolerated also in open fractures. For unstable segmental fractures and for unstable fractures of the middle third of the shaft, the Lottes nail gives excellent results. Many of these fractures permit blind nailing without the necessity of exposing bone, but the nail has also been well tolerated in open fractures. Our policy is not to nail an open fracture primarily if there is even moderate contamination. Plates should be reserved for unstable short oblique or small butterfly fractures at either end of the middle third, especially the proximal end, where the fracture architecture would not be adaptable to the use of screws, bands or nails. Plates, as observed in this study, have not been well tolerated in open fractures.

The more extensive the comminution of the fracture site, the less inclined the surgeon should be to apply internal fixation. A very comminuted fracture usually does not threaten to erode through overlying soft tissues and can be well managed by closely supervised os calcis traction, especially if the level of the fracture is in the lower third of the tibia. Unmanageable patients may occasionally need double Kirschner wire transfixion of the tibia below and above the fracture site and incorporation in a long-leg cast in instances when comminution is too severe for other methods of internal fixation.

If there is obvious clinical free motion at the fracture site in non-comminuted fractures of the tibia at four months or in six months in comminuted cases, in the absence of infection, autogenous bone grafting should be done and, if possible, better internal fixation applied. One should wait longer for healing, however, if there has been infection, for it might be reactivated by such surgical efforts.

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Mass Leg Casualties

MANAGEMENT OF TWENTY-EIGHT SIMULTANEOUS LEG FRACTURES

FLOYD E. BLIVEN, JR., M.D., *Augusta, Georgia* AND J. D. MCARTHUR, M.D., *Lyons, Georgia*

ON July 31, 1957, the infirmary of the Georgia State Prison in Reidsville was notified of the imminent admission of forty-one patients with leg injuries. These patients were prisoners of a rock quarry prison camp who had organized the leg-breaking incident as a demonstration of protest. Details differ but one description by a prisoner observing the occurrence provides the setting and suggests the mechanics of injury.

Said the witness: "I was sitting there on the ledge watching them. They laid their legs across two stones. Three men came down the line with hammers breaking their legs. They were using twenty pound hammers. I could hear the bones crack. They would holler some, and turn aside, but they didn't holler too loud." This desperate interlude was carried out during the rest period within about fifteen minutes.

None was able to walk; many had bleeding abrasions and lacerations at the site of impact. A few presented deformity, but in the larger number the fractures, although probable, were not obvious by inspection. First aid included cleansing the damaged skin, application of merthiolate® and application of dry sterile dressings. The group was transferred by ambulance to the prison infirmary 300 miles away. During the trip the injured extremity was splinted by stretcher, blanket and pillow.

At the infirmary the men were processed as they arrived, getting x-rays with the routine two views of the injured leg, and then were placed in bed for evaluation. Hospital records were initiated and the medical staff with the orthopedic surgeon recorded examination of patient, x-ray examination, medical orders and plan of management of each patient in succession. Most patients showed little pain once in bed with the injured leg resting on a pillow, usually in the position of injury. It might be noted in considering pain that patients were in beds lined up close to each other in three large rooms with security personnel present. Those with considerable discomfort received morphine before application of the plaster cast.

TABLE 1
INJURIES INCURRED

Injury	No.
Soft tissue injury only	8
Fractures of tibia and tibia-fibula	28
Other fractures:	
Fibula, shaft	2
Bimalleolar fracture of ankle	1
Fibula, lateral malleolus	1
Cuneiform bones of foot	1
Total	41

Initial evaluation showed that despite the similar mechanism of injury there was a considerable range of injuries. Table 1 is a tabulation of injuries for the entire group. The larger group and those presenting the problems in management involved mid-shaft fractures of the tibia and fibula; in two cases the tibia was fractured without breaking the fibula.

TREATMENT

The pattern of management presented hereafter allowed completion of initial care of the group within twelve to eighteen hours.

Local Care of Skin and Soft Tissue Wounds. All legs were swollen, usually with prominent pretibial swelling. In the less severely injured an area of contusion and hemorrhage marked the impact of the hammer. The more severe

open wounds were more abrasions than lacerations, often exposing areas of beaten, swollen, bleeding muscle, subcutaneous tissue and skin. The skin edges were jagged and bruised. These wounds were carefully scrubbed with soap and water and covered with vaseline gauze

TABLE II
MANAGEMENT OF FRACTURES OF TIBIA, AND TIBIA AND FIBULA

Management	No.
Application of long-leg cast in dependency (only procedure)	17
Reapplication of cast with change in position	1
Wedging of cast to correct alignment	4
Closed reduction with anesthesia (successful)	1
Closed reduction with anesthesia (unsuccessful)	6
Open reduction, no fixation	1
Open reduction, intramedullary fixation, iliac bone graft	2
Open reduction, metal plate fixation, iliac bone graft	1

and a dry, sterile dressing. All were left open. Sharp débridement was not done.

Antibiotic Therapy. Patients with moderately severe contusions and all with open wounds received penicillin initially and for one week.

Tetantus Prophylaxis. The group receiving antibiotic therapy also received tetanus antitoxin.

Treatment of the Fracture. The fracture of the tibia or tibia and fibula was immobilized in a well padded long-leg cast. This cast was applied with the patient supine, the involved leg being allowed to fall to a position of dependency over the edge of an operating room table, and the foot held in a neutral right angle position by an assistant. In this position the muscles are relaxed, alignment of fracture fragments is obtained without effort or anesthesia and position can be maintained as the plaster is applied in a continuous procedure from toe to groin. Check films of the long-leg cast found the position of the fragments satisfactory for the larger number of cases.

In the cases in which angulation and displacement were uncorrected by this procedure the cast provided immobilization in a position of comfort while awaiting the subsequent procedures as presented in Table II.

In the smaller degrees of angulation and displacement, correction could be obtained during the first month by wedging the cast. In one case at the time of change of cast, a new position was obtained reducing the angulation deformity. Closed reductions were carried out in seven cases but in only one was a stable

TABLE III
PATIENTS DISCHARGED TO FULL ACTIVITY AND WORK

Fracture Type	Months After Injury					
	4	5	6	7	8	12
Group 1:						
Transverse undisplaced	64%	91%	100%	....	.....	.....
Group 2 and 3:						
Moderate angulation, displacement and fragmentation	....	....	33%	75%	100%	.....
Group 4:						
Unstable	....	....	.....	20%	60%	100%

fracture demonstrated and position improved beyond that obtained in the initial application of the cast.

Early open reduction and fixation allowed early healing in two cases (Cases 26 and 28), and in two others (Cases 16 and 24) position was improved by later open reduction. For this group of fractures, early reduction and use of an intramedullary nail is advocated since this converts the unstable fracture to a stable type. A ¼ inch Vitallium Rush-type nail was used. This method of fixation allows reduction without extensive periosteal stripping; iliac cancellous bone was used at the site of expected callus. The fracture was protected during healing with a long-leg cast; however, partial weight bearing was allowed when new bone was evident in the x-rays. Bone plate fixation was used in one case (Case 24) with an iliac graft. Other fractures were minor. The fibular fractures were managed with partial weight bearing but no cast. The malleolar and foot fractures were immobilized in a plaster boot.

RESULTS

Recovery was favored because of the youth of the patients and their prime physical condition. Furthermore, each patient was followed up through his recovery period in the infirmary and for a period of observation while increasing his activity.

Healing and return of function appeared to follow a pattern related to the four types

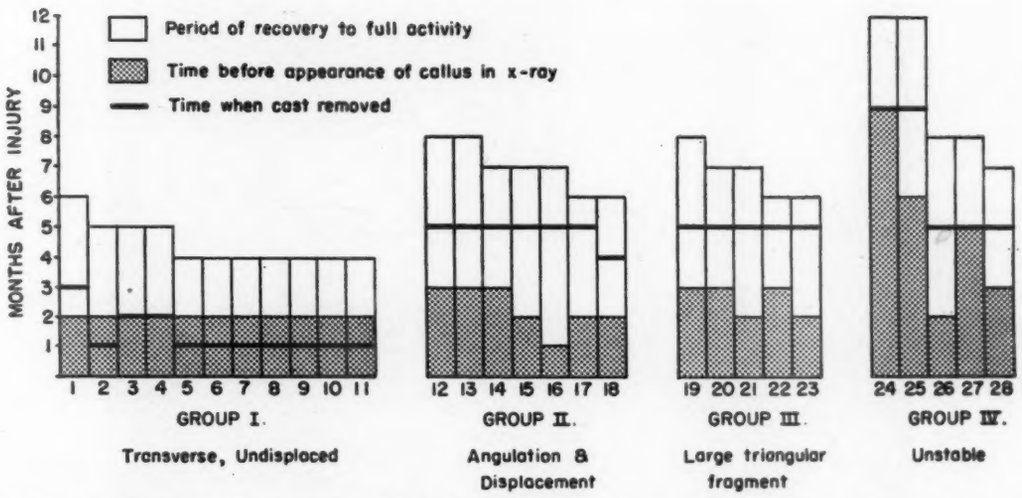


FIG. 1. Summary of fractures of tibial shaft, illustrating the patterns of recovery. Cases are numbered as mentioned in text.

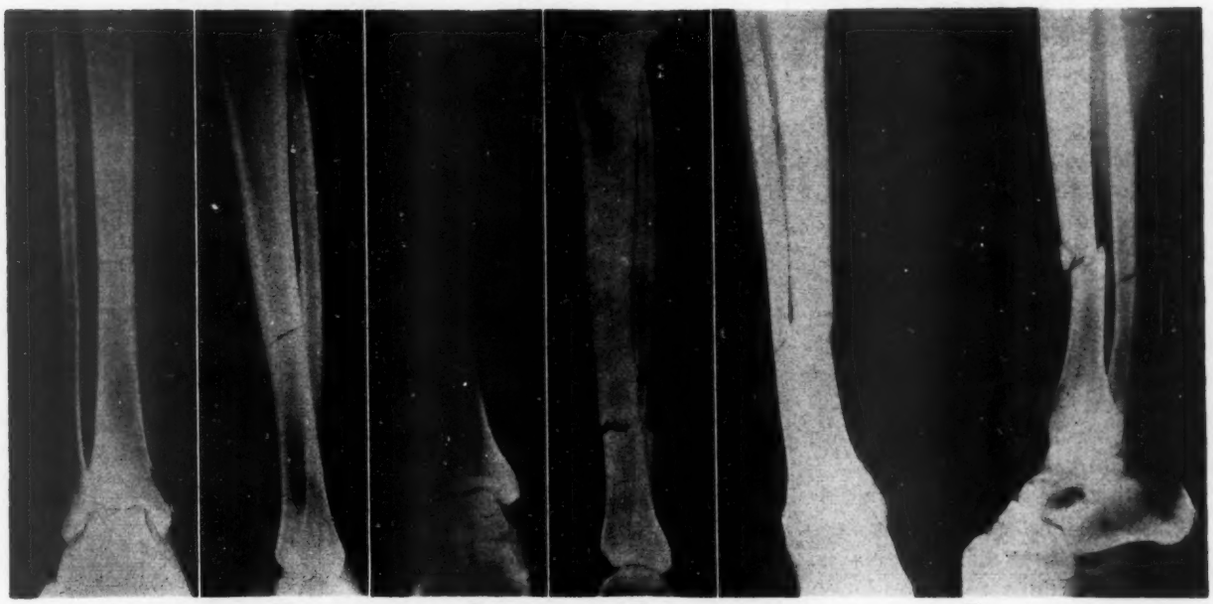
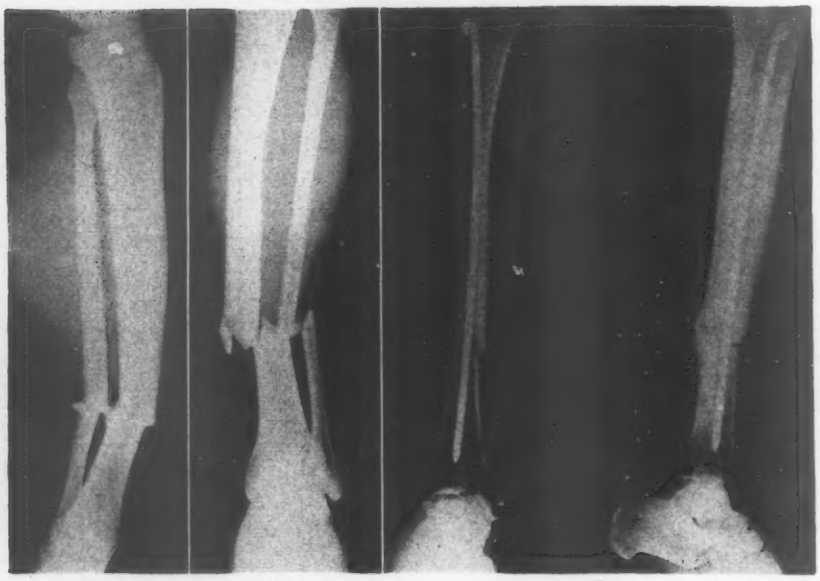


FIG. 2. Fracture classification. A, B, group 1, transverse fracture without displacement or angulation. C, D, group 2, transverse fracture with moderate displacement or angulation. E, group 3, transverse fracture with large triangular fragment.

of fractures as pictured in Table III and Figures 1, 2 and 3. Over half the group with undisplaced transverse fractures returned to work after four months. By the end of the seventh month after injury all patients in this group and three-quarters of those with fractures with moderate deformity were returned to work. Of the unstable fractures, only the two patients having early open reduction had comparable recovery.

The criteria of healing sufficient for weight bearing in a cast and for unprotected weight bearing vary with surgeons. In this series partial weight bearing was begun when the callus became visible in the x-ray, which in the transverse and stable fractures occurred in about six weeks. The principle underlying this management is that the position of fracture fragments should be protected from bending, torsional and weight-bearing stresses



3A 3B 3C

FIG. 3. A, B, group 4, unstable fracture. Closed reduction unsuccessful. C, these were treated by early open reduction and intramedullary fixation and iliac graft.

while the callus is forming, but that once calcification in callus is visible, the stimulus of protected partial weight bearing enhances recovery. In the undisplaced transverse fractures in group 1, all patients were out of the cast in three months; in the remaining patients only two remained in plaster longer than six months.

It was observed that mineralized callus appeared almost uniformly in the eight- to twelve-week interval after injury. The three exceptions are of interest since they appear to illustrate delayed healing. One patient (Case 24) had a badly displaced fracture with operative intervention delayed by failure of the skin lesions to close. Open reduction was carried out at six months and callus was definite three months later. The other patients (Cases 25 and 27) had the most severe soft tissue wounds in the series. These wounds healed with epithelized scar during the fifth month and promptly thereafter the bone healed.

The results approximate other reported series.

COMPLICATIONS

From a review of the complications emerge some of the limitations in the treatment of this group of patients, as well as suggestions for improvement of similar problems in the future. (Table IV, Fig. 4.)

The soft tissue wounds were difficult to manage since tissue injury was poorly defined and, in addition, the wounds were seen about eighteen hours after injury. Combined soft tissue and bone injuries always present difficulties. Most of these skin lesions healed quickly with local conservative care which was carried out through a window in the cast; however, windowing modifies immobilization of the fracture fragments. In two cases with an open window in the cast there was an increase in angulation of the fragments; position of the fragments should be checked at frequent intervals and recumbency probably maintained until callus is established. In the three

TABLE IV
COMPLICATIONS

Complications	No.
Wound infection (soft tissue)	1
Bone infection	0
Delayed union	3
Non-union	0
Deformity (moderate):	
Displacement	2
Varus	1
Valgus	1
Posterior bowing	6
Muscle atrophy	10

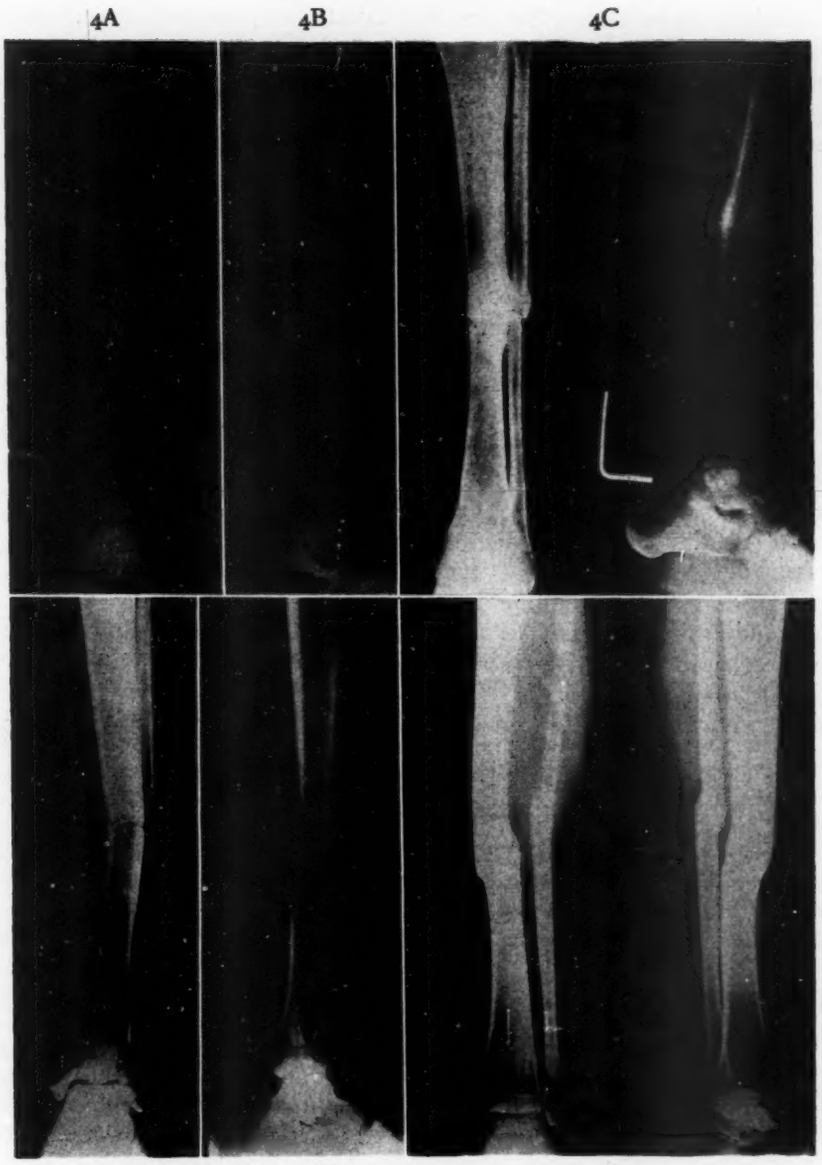


FIG. 4. Complications. A, B, Case 27. Displacement deformity but good alignment resulting in excellent function and no symptoms. C, Case 22. Posterior bowing with displacement of weight-bearing line to posterior ankle joint. D, E, Case 15. Varus deformity. F, Case 19. Valgus deformity. None presented disability.

more severe wounds, early sharp débridement of the wound surface and split-thickness grafts might have allowed early open reduction and prevention of deformity.

Posterior bowing in this series seems to represent the tendency for the original fracture deformity to recur after absorption at the fracture site. Wedging in the first four weeks while the callus is soft may correct this angulation. The valgus and varus deformities can be similarly corrected. The two complications of surgery occurred in the same patient and were due to involvement of nerve in the exposure of the tibia. There was both motor and sensory loss which subsequently improved. Displacement deformities could have been prevented by open reduction, as mentioned heretofore. There were no cases of non-union or infection of bone in this series.

Atrophy of muscle has been noted and was

seen in almost all patients in plaster for longer than four months. The muscle volume and strength improved as activity was regained but the atrophy was a cause of limp and appeared to be the single factor limiting work after discharge in the slow recovery patient.

SUMMARY

1. The management of a series of forty-one simultaneous leg casualties is presented. Injuries similarly incurred included a range of severity.

2. The large number of leg fractures were treated by application of a long-leg cast to the lower extremity in a position of dependency.

3. For fractures found unstable by this procedure, early open reduction with intramedullary fixation and iliac graft is advocated.

4. Posterior bowing of moderate severity not presenting disability was a frequent complication of this bending stress injury.

5. A majority of the patients with fractures of the tibial shaft were returned to work within six months, and all the patients within one year.

Acknowledgment: We wish to acknowledge and thank Mr. Rufus P. Balkcom, Jr., Warden, Georgia State Prison, Reidsville, Georgia, for his support and interest in the initial management and recovery program of these patients. We express our appreciation to the Infirmary staff for their careful work.

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DISCUSSION OF PAPERS BY DRS. GARCIA AND NEER; WADE AND CAMPBELL; AND BLIVEN AND MCARTHUR

Oscar P. Hampton (St. Louis, Mo.): I would like particularly to discuss the paper on fractures of the tibia presented by Drs. Wade and Campbell.

There are two or three points that need a great deal of emphasizing, it seems to me. First and foremost, Dr. Campbell rather sloughed over those splendid results with non-operative management. As much as I like to operate (they accuse us of running a knife and needle service, and we do not deny it; the needle is for hydrocortone with apologies to Dr. McLaughlin), one has to admit that they have demonstrated splendid results in fractures treated by cast alone.

Dr. Bohler, I am told, in his postgraduate course in Philadelphia last year, made the statement that they had given up entirely the operative treatment of fractures of bones of the leg. One does not want to subscribe to that or there would not be any fun in fracture surgery. However, one has to respect what this old gentleman has said on the basis of his great experience.

I want to talk a little bit about intramedullary nailing. It seems there are a few converts after years of effort. If one is to nail a tibia, the Lottes triflanged intramedullary nail certainly is the best nail we have.

To get the best results, as I attempted to emphasize last year at Santa Barbara, one should decide on the method promptly, apply it promptly, and in closed fractures use it with a closed reduction of the fracture. If one delays while trying one or another non-operative method, and a week or ten days later decides to use intramedullary nailing, then one usually has to open the fracture site. When the fracture site is opened we have all the hazards of failure of wound healing from ischemic flaps, infection, etc.

I would like to discuss how we achieve closed reduction. The position of the patient on the table allows a flexed knee over the end of the table. Considerable flexion of the knee, about 90 degrees, is essential in order to get a vertical take-off which is mandatory. The slot is gradually enlarged so that it will freely admit the nail. Then the nail is driven downward; a tremendous backward pressure on the nail has to be used in order to get that vertical take-off. A high take-off is crucial. The higher the take-off, the more one can maintain the vertical thrust of the nail. With the nail driven to calculated depth, the operator performs the closed reduction. This is not hard in a fresh fracture. One can feel the fragment ends and line them up while traction is made downward. When it is obviously, or at least apparently, reduced, then the nail is driven across the fracture site.

A check film is often taken. With increasing experience this is not necessary. Later, one should always take a check film to see that the nail has been driven in far enough.

Of course, we use a long-leg cast. Some people around the country are advocating no plaster for these. I cannot see any great advantage, and there are many disadvantages, but we have no time to go into them all.

I would like to mention a fracture to which other methods of internal fixation might not be applicable—the open fracture. An intramedullary nail may be used in open fractures with just as much safety or with no more hazard than with plates or multiple screws. If metal is to be employed, use the best for the fracture even though it requires a long piece of metal going down the medullary canal. One does this with no additional periosteal stripping and without crowding closure. Most of the failures of wound healing are from ischemia and not bacteria. One can employ such a device in a comminuted or open fracture without too great a danger of infection.

PRESTON WADE (closing): Regarding the paper by Drs. Garcia and Neer, I can only remember one case in the last two years, similar to the one they described, that we have operated upon. I was amazed that they had forty cases of this type. Our case was associated with a medial collateral ligament tear with dislocation of the knee necessitating operation. Preoperative x-rays did not divulge the entire pathologic condition and with some difficulty we fitted it together. The tibial spine, however, fitted in place well and was held with a wire.

Dr. Quigley, who could not be here, commented as follows on Drs. Garcia and Neer's paper:

"I agree completely with your conclusions except that I think I would be a little more free with open reduction. As you have indicated, this fracture is often associated with collateral ligament and meniscus injuries which are better treated, when severe enough, by prompt early surgery than watchful expectancy. I have found that it does not add much to the operation to put a drill hole up from the tibia and pass a wire loop around the fracture, and motion generally can be started fairly soon. In old cases, I certainly agree that formal reconstruction after the manner of Palmer with fascia is simply not worth the surgery involved."

I would like to say a word about the paper by Drs. Bliven and McArthur. It is amazing to imagine those forty men lying there, having someone come along and break their legs with a hammer and not cry out. When I found out that they went back to knocking rock from six to six, I realized there may have been some reason for their doing it. However, if they had read the results of our paper, I think they might have chosen another method to avoid work. The treatment was obviously excellent, and the results are as good as any you will find.

I think that the man who hit the prisoners with the hammer did it in a favorable site in the bone for union—in the middle of the shaft and not at the junctions of the lower and middle third. Furthermore, I think that although there was considerable trauma, the trauma was to the skin over the subcutaneous tibia without much associated soft part involvement as one might get in an automobile accident. Therefore, the infections were not severe and there were not many. I think that is something to think about. This was an ideal situation for those with open fractures, and I think the method of treatment cannot be criticized.

I do like the Lottes nail better than the Rush nail because I think it holds better. I think there is a place for the Lottes nail.

That leads me to say, Dr. Hampton, that you have not converted me to using the Lottes nail on all fractures of the middle two-thirds of the tibia, but I admit it certainly has a place in a large group of fractures that cannot be treated as well in other ways. You see, we had very good results with those; there were no instances of non-union or infection, and the number of cases was small. (I think it was seventeen.) We are pleased with the results.

In other words, I think it must be pointed out that the method has dangers and must be used, as you say, by someone who knows how to perform it and who is careful. I shudder to think what might happen one day if a bad infection developed or we explode a bone. Then we might not be so impressed with the method.

It is impossible to report all of our findings, but this is the way we feel about our tibial fractures. Many can be treated by plaster alone, as I pointed out. Those that are stable do best with plaster alone. There are many that are best treated by traction and plaster. With those our results were very good, with no complications, and no delayed unions resulted.

We do operate, of course, and we like to use as little metal as possible, two screws, if possible. We are very disappointed with our plates, but we rarely use plates in the tibia any more. We think there is a place for the plate in certain groups of cases. We used a Parham band in a few cases and we advise that it be taken out.

One thing I am personally very disappointed about is that I have been advocating the use of primary iliac bone graft in closed fractures at the junction of the lower middle third. It gives an opportunity to put in the graft early, and I thought certainly it would show a very definite improvement in rate of healing. However, our cases did not show any more rapid or better healing than the ones in which we had not inserted the graft. We are continuing to use the graft, however, in certain cases. A careful technic is needed to avoid increasing the bulk of the leg too much so as to cause tension on the wound and, therefore, lead to sinus formation and infection.

In our open fractures we do not use bone grafts, of course, but do primary closures if possible. We emphasize to the students that primary closure can only be done in early selected cases in which contamination is slight and in which there is little

soft part injury. This does not apply to military casualties or mass casualties. We try to perform closure, and we always prepare to make a relaxing incision and skin graft, so as to have no tension on the wound. To close a wound and have tension invites sinus formation and infection.

JAMES K. STACK (Chicago, Ill.): I saw an article in a Chicago paper about this episode in the Georgia prison camp, and I said to myself, "This is right down our Association's alley." So, I wrote to the Georgia prison camp and, in due time, got a nice note from Dr. McArthur. He said that he required the able help of Dr. Bliven, who is Chief of Division of Orthopedics of the Medical College of Georgia, and that he and Dr. Bliven would report this episode to us.

In two or three of these papers, certain principles were brought out which I would like to emphasize.

First, I would like to congratulate Dr. Campbell for using the terms "open" and "closed," rather than "simple" and "compound." The Trauma Committee of the American College of Surgeons has been trying for about five years now to have this terminology adopted. This suggests that it is beginning to take hold.

Second, Drs. Wade and Campbell's case, that of a child with considerable displacement who did very well with plaster immobilization, brings up the principle enunciated by one of our members, Charlie Wood of Louisville, who one time said that in fractures in childhood, if you can keep all fragments or most fragments in the same limb, you will do well.

Third, all of these questions of immobilization, whether it is open or closed, come back to the same point. Many years ago, while in college, I worked during the summer for a construction company. One day the engineer took me up on a mound of earth and pointed out over the job. He said, "You know, Stack, there are three principles in the building of a good road. The first is adequate drainage; the second is adequate drainage; and the third is adequate drainage." There are three principles in getting good results in these tibial fractures. The first is adequate immobilization; the second is adequate immobilization; and the third is adequate immobilization.

F. M. SMITH (New York, N. Y.): I was slightly amazed at the high incidence of non-union that Drs. Wade and Campbell cited in their series, particularly in the closed as well as the open fractures. I do not have the exact statistics, but since 1938, when we changed from vanadium steel to stainless steel as a method of internal fixation, I can recall only one definite case of non-union following open reduction and internal fixation of a closed fracture. Dr. Neer tells me he had one other within the last four or five years. That would make but two, and we have not used bone in addition as a bone graft.

I would also like to mention one caution. One perhaps should use additional bone as a bone graft. Just recently, however, I heard of a case in which the surgeon put the additional bone on the lateral surface of the tibia, i.e., between it and the muscle. He promptly shut off the blood supply from pressure on the anterior tibial artery and gangrene of the foot ensued.

In one of the cases of Drs. Wade and Campbell it seemed to me as though several fragments had been removed in addition to perhaps not having exact end-to-end apposition. I do not believe anyone should remove fragments in that type of fracture. You are doing just the opposite from adding bone; you are subtracting bone, and praying for a non-union.

I was delighted to hear that they did not perform open reductions on children or use any internal fixation. Some of the instrument companies are advocating various types of nails for internal fixation in children's fractures. They say, "So-and-So has excellent results with these in children." I think it is a horrible thought and should be condemned.

RONALD ADAMS (Boston, Mass.): It is a fact that frequently this fracture is missed.

At one time, I had to look up a series of these cases I had seen, and report on six or eight of them. I have seen about that same number since that time.

I think there are two clinical points that may be of use to us. One is that when there is a very slight displacement of the tibial eminence, the routine posteroanterior and lateral views will fail to show the fractures in a high percentage of cases. However, an oblique view of the knee at that point will show the fractures much more frequently than the routine views.

Second, this is a sprain fracture, and whether or not you see a few abrasions around the knee joint is immaterial. The real fracturing force is transmitted through the collateral ligaments into the cruciate ligaments with avulsion of the tibial eminence.

Attention is rightly called to the soft tissue injuries that occur. With early reduction, and the knee held in extension and adequately immobilized for a period of three or four weeks, I have never seen one of these go on to non-union. Very few of them will require open surgery, but the inexperienced surgeon may be surprised at the amount of soft tissue thickening and the limitation of motion for a long period afterward. Obviously, it is the soft tissue injury that produces the long delay in restoration of function. If one is patient in waiting for an end result, usually a full restoration of motion will occur if proper reduction has been obtained.

ROBERT H. KENNEDY (New York, N. Y.): In regard to the most interesting presentation of Drs.

Bliven and McArthur, there must have been a ringleader who started the epidemic at Georgia State Prison. It would be interesting to know if the ringleader was ever discovered and whether he participated in the application of the hammer to his own leg, or whether he simply stood aside and acted like a general. I suppose there is an underground newspaper in the state prison system of Georgia. There must be one among the men. I wonder whether this ringleader has since surveyed the situation, as has been so well done by the authors, and discovered some means—since these people apparently do not want to work—of getting a longer period of no work by a different type of fracture. I think we should watch for the next epidemic.

JOSEPH M. DZIOB (Buffalo, N. Y.): The spine fracture in the knee is, of course, an avulsion fracture. I would like to ask a question regarding this. If it is true that in avulsion fractures immobilization is performed with the ligamentous structure in the position of relaxation, is it not also true that the anterior cruciate ligament is most relaxed with the knee in the mid-position?

ALEXANDER GARCIA (closing): First, Dr. Wade, I would like to put your mind at ease. None of these cases that came in late were from New York Hospital.

Regarding Dr. Quigley's comments, although one would think that the meniscus injury would be something you would find commonly with this injury, the three cases that subsequently required meniscectomy were those in which the fragments were undisplaced and considered relatively minor. The only treatment was immobilization and the patients were seen only in the outpatient department. I think it is probably better to be slow with the knife rather than fast in displaced fractures. I see no occasion for surgery in these cases with no displacement and merely an effusion, if extention to 180 degrees can be achieved.

I agree completely with everything Dr. Adams said, and think the slow return of function is very true. Just as he said, this is a manifestation of the ligamentous damage that goes along with the fractures, and we like to think of this injury as an attempt of the knee to dislocate. We had one patient who dislocated his knee on the football field, and his fellow players put the knee back. He had an undisplaced fracture and tear of the lateral collateral ligament.

As to the question of when the anterior cruciate ligament is relaxed and when it is not, that has been bounced around by many people. Apparently this ligament can be relaxed in flexion or in extension, depending on what portion of it you are considering. Just from the practical point of view, in most of these cases we are interested primarily in preventing callus from forming and elevating the intercondylar eminence, because it was the callus and the scar that blocked extension in the cases in which we have explored and have not obtained reduction.

ROLLA D. CAMPBELL, JR. (closing): I agree with the discussers very much indeed with regard to the fact that immobilization is the crux of the matter in treating fractures of the tibia. I also wish to state to Dr. Hampton that I did not mean to slough over the good results obtained by this method. I was trying to observe the three cardinal points of public speaking that Dr. Wade told me—stand up, speak up and shut up. Consequently, we had to brush over some of these things.

I would like to quote the conclusion of our paper. (Dr. Campbell read the conclusion.)

We think it is very important to recognize the type of unstable fracture initially which is suitable for internal fixation and to apply the latter promptly before blistering and induration of the skin have occurred.

In regard to the discussion by Dr. Smith, I had made previous notes on the article by McLaughlin et al. from Presbyterian Hospital in 1949 although it was not referred to in this paper. The experience at Presbyterian Hospital in internal fixation then included an average healing time of 4.6 months for sixty-three patients and 7.7 months for seventy-four patients with open fractures. There were no non-unions reported in the closed fractures, and six in the open fractures (8 per cent). I think most of those involved the tibia, as best I could interpret the article.

In connection with our failures, I have to make this remark for Dr. Wade. Three of the patients with non-union reported with the use of plates came to us with infection from elsewhere and we included them as evidence of the problems connected with the method, although they were not initially in our hospital operating room.

FLOYD E. BLIVEN, JR. (closing): The experience we encountered at Georgia State Prison was an unusual one, and you could hardly have a more controlled group: they were in prime physical condition, actively at work and all in the younger age group; the force applied was the same: 23 pounds, 36 inches. What this produced was a bending fracture almost exactly at the same level in each case. One difference was that the Negro patients did not have as severe an injury as the first group. At first I felt we were titrating the strength of the bone, but I discovered later that most of the Negro patients were men who had put the leg over one stone rather than two stones. The engineers say that there is a very great difference in the impact involved.

I have nothing further to add to the comments. We will try using the Lottes nail again. We did in the past, but feel at the moment that the Rush pin has some advantages. It all, of course, comes back to the matter of immobilization.

Ruptures of the Quadriceps Tendon

STUDY OF TWENTY TENDON RUPTURES

CARLO SCUDERI, M.D., PH.D., *Chicago, Illinois*

RUPTURES of the quadriceps tendon are quite infrequent when considering all types of injuries about the knee joint. Perhaps this is because the type of mechanism necessary to rupture the quadriceps tendon will more frequently fracture the patella, detach the patellar tendon or produce a supra- or dicondylar fracture of the femur.

TABLE 1
ANALYSIS OF TWENTY CASES OF RUPTURE OF THE QUADRICEPS TENDON

Number of patients	18
Bilateral ruptures	2
Unilateral ruptures	16
Extremities involved:	
Right	13
Left	7
Age in years:	
Range	24–70
Average	48.2

The tendon defect may not be readily detected due to the hematoma formation about the knee which is associated with this injury. In addition, x-rays taken reveal no fracture. With the patient supine and the knee in the extended position there is no appreciable drop of the patellar level. For this reason, some ruptured quadriceps tendons are not recognized for several weeks following the accident until the swelling subsides and the patient is found to have lost active voluntary extension of the knee.

I treated the following group of cases from September, 1938 to August, 1955. These have all been treated in private or charity practice, exclusive of military service. Not one case was seen during my military experience when I was in charge of orthopedic surgery in one of the large general hospitals in the zone of the interior, for approximately two years.

Eighteen patients with twenty ruptures of the quadriceps tendon were treated. (Table 1.) Two patients had bilateral ruptures; one was a woman of seventy and the other a man of sixty-eight years of age. In both cases only one leg required surgical repair, the other side having an incomplete tear. The power of voluntary extension of the knee was very weak, but present. In time almost complete return of the quadriceps strength was attained in the unoperated leg.

Three patients were seen late, one at six weeks who refused surgery in spite of the fact that he was unable to go up or down stairs without holding on to the banister. Another was seen at seven and one-half weeks with about 60 per cent tear of the quadriceps, but with good range of voluntary knee extension, although weak in quadriceps power. The third case was a priest who had injured his knee ten weeks previously and went elsewhere for the surgery. The end result of this case is unknown to me.

Two of the patients had been operated upon in neighboring states and were referred to me for follow-up care because they lived in Chicago.

I operated upon thirteen patients and observed them from eight months to two years thereafter.

Two cases were the result of direct cutting injuries, one the result of a knife wound and the other the result of a windshield cut caused by a head-on collision.

Eighteen ruptures were the result of indirect violence. The patient either tripped or fell, the knee or knees buckled, and apparently one, two or all three of the following prerequisites were present: (1) violent contracture of the quadriceps muscle in an attempt to break the fall, with the knee partially bent; (2) an ex-

tremely violent leverage action from acute flexion of the knee by a force being applied at the foot or toes; and (3) degenerative changes of the tendon, the result of obesity, advancing age or occupational requirements of frequent and prolonged kneeling with wearing thin of the quadriceps fibers.

The results of the operative cases were excellent or good in eleven of the operated cases. This meant complete return of extension with not more than 15 degrees' loss of flexion of a possible range of about 145 degrees.

One case was classed as fair in a seventy year old woman. The patient was very fearful of bending her knee because she thought the tissues would pull apart, and she refused physical therapy.

In one case, a tabetic patient, a skin slough developed with secondary infection and this was classed as a complete failure. The tabes was probably purely incidental to this unfortunate outcome.

HISTORICAL SURVEY

Without much doubt, ruptures of the quadriceps tendon have been occurring since man first exposed himself to sudden violent flexion of the knee.

The first recorded mention of a ruptured quadriceps tendon is found in the work of Galen [4].

In more modern times, Rusch [4] in 1720 published a work on this entity.

Up to the time that Lister [4] performed the first surgical repair with the use of antiseptics, the treatment of this condition was medical.

In 1887 McBurney [3] was the first to publish the results of a single operated case in the American literature. In this case he approximated the tendon by the use of catgut, the silver wire to reenforce the attachments through drill holes in the patella.

In 1896 Waller [19] collected and reported on 115 cases from the literature up to that time. In 1909 Heineck [10] collected and reported on fourteen cases from the files of the Cook County Hospital. In 1927 Gallie and Lemesurier [6] reported on six cases in which they had operated and repaired the injury with the use of fascia lata strips.

Milch [16] in 1931, Meyerding [14] in 1935, Conwell and Allredge [5] in 1937, James [11] in 1938, Conway [4] in 1940 and Graney [8] in 1943 published individual case reports numbering from single to multiple cases.

Most recent contributions of additional personal cases were made by Michele and Kreuger [15] in 1949, Steiner and Palmer [18] in 1949, Goldenberg [7] in 1949, Wetzler and Merkow [20] in 1950 and Hanlon [9] in 1951. These varied from one to eight cases.

Each of these authors described his method of repair using catgut, silk, fascia lata or kangaroo tendon. All were in agreement that if a tear existed with loss of voluntary knee extension, surgical repair was imperative.

ETIOLOGY AND PATHOLOGY

In elderly, obese people, degenerative changes of the quadriceps tendon is undoubtedly the predisposing cause.

The two oldest patients in this series had bilateral ruptures of the quadriceps tendon, showing that something must have been structurally weakened in both tendons of both patients. The seventy-year old woman caught her heel while getting off a motorbus, falling to the pavement. The other case, a sixty-eight year old man, slipped and fell on some ice while making his rounds as a watchman.

Undoubtedly some of the fibers of the quadriceps must undergo degenerative changes from the wear and tear of life and eventually a violence, which ordinarily would cause no trouble, pulls these weakened fibers apart. Perhaps this can be the same type of change which slowly thins the abdominal structures, and eventually a direct hernia occurs in the inguinal region from a rather insignificant injury. It may be similar to the wearing out of the seat of one's trousers. Day by day the threads get thinner and thinner, and suddenly from simply stooping over the entire gluteal area tears.

In 1951 Lang [12] published a very excellent article on the pathological changes that take place in the quadriceps tendon with advancing age. Fatty degenerative and tendinosclerosis were found to a marked degree in elderly people.

His pathological study was based on eighty quadriceps tendons in patients between the ages of sixteen and eighty-six years.

Speed [17] was of the opinion that there was an extensive decrease in the collagen in the tendon fibers associated with fibroid degenera-

FIG. 1. This section that was taken seventy-two hours after the quadriceps tendon was ruptured in a forty-one year old man. Hematoxylin and eosin stain, original magnification ×170. In the center of the field is the inflammatory reaction secondary to trauma, characterized by lymphocytes, plasma cells and histiocytes with ingested red cells. In this area can also be seen the fragmented tendon. In the upper right portion of the field is the acellular tendon indicating degenerative changes of hyalinization.

FIG. 2. Higher magnification of Figure 1. In the center of the field is seen the exudative reaction with hypertrophy of the endothelial cells. To the right of the center of the field is a portion of the tendon which is acellular and fragmented. Hematoxylin and eosin stain, original magnification ×220.

tion or infiltration of the tendon which lends itself to this easy rupture.

In younger patients the etiological cause may be a direct cutting injury as occurred in the two cases reported herein, one from a knife and the other from a broken windshield.

In persons in their prime of life the disruption of the tendon can only occur from considerable force of muscular contraction of the quadriceps muscle on one side and the lever action of the leg from the knee to the toes on the other side.

The actual moment of tearing occurs when the knee is in the semi-flexed position, the patella firmly held against the anterior aspect of the femur by the pull of the quadriceps muscle and the force continuing. The upper pole of the patella cannot be torn off because it is buttressed against the femur, so the tendon shreds and separates.

The tear first occurs in the central portion of the tendon most anteriorly, because this portion of the tendon is the first to take the brunt of the force. After this portion gives way, if the force continues, the medial and lateral fibers tear. The extent of the tearing depends on the amount and duration of the force.

In all but one case, which was operated, the tear had been relatively transverse with jagged edges along the margins of the separation. In only one case was the tendon torn at about a 45 degree angle.

Usually the tear was about ½ to ¾ of an inch (1.3 to 2 cm.) from the superior pole of the patella. In no instance was the periosteal attachment of the tendon to the patella disrupted.

Because of the loss of the constant tonic contraction of the quadriceps tendon, the patella drops to a slightly lower level on the femoral condyles, and can be moved freely over a wider range in the medial lateral axis.

A large hemarthrosis and subcutaneous ecchymosis follows the tear. Absorption of this hematoma will take several weeks if not evacuated surgically.

The quadriceps tendon now has lost its distal attachment so it rapidly draws proximally and within a period of several weeks may have contracted proximally about 2 or more inches (5 cm.). If this condition is permitted to exist, fibrosis of the muscle takes place with loss of elasticity of the muscle fibers making it very difficult or impossible to reapproximate the torn edges of the tendon. The major changes take place in the rectus femoris, and to a minor degree in the vastus medialis, vastus lateralis and vastus intermedialis.

Figures 1 and 2 show the microscopically pathological changes in a recently operated patient, age forty-one, who was obese and appeared outwardly about ten to fifteen years older than his chronological age.

Figure 3 shows the interior of an operated

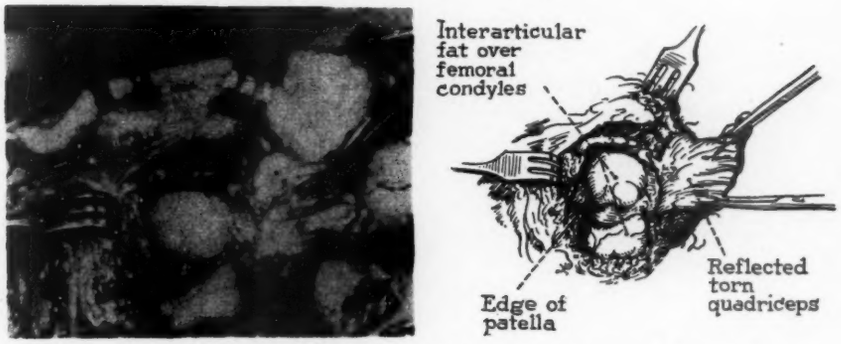

FIG. 3. Interior of an operated knee joint showing the surgical pathology.

joint with the torn quadriceps tendon, the upper margin of the patella and the intra-articular fat.

SIGNS AND SYMPTOMS

The cardinal symptom in rupture of the quadriceps tendon is the inability of voluntary extension of the knee. An associated symptom is loss of complete control of the leg on attempting to ascend or descend stairs because of the complete instability of the knee in the flexed position.

Stationary standing is possible but active locomotion is impossible if the tear is complete.

After the original knife-like cutting pain which occurs at the time of the accident has subsided, the element of pain is minimal. This is true because there are no raw bone surfaces rubbing together, and the nerve elements in this area are not too sensitive.

Objectively, one immediately notices a profuse hemarthrosis with an especially prominent bulge where the hematoma becomes subcutaneous through the area of the disrupted tendon. On palpation one can readily feel the anterior aspect of the femoral condyles and supracondylar area because all that separates the examining fingers from the bone is skin and some subcutaneous fat.

Due to the loss of the quadriceps muscle tonicity, the patella lies at a slightly lower level than normal. This is especially true when the patient stands erect.

The x-rays will show no pathology in the knee area, unless soft tissue technic is used. The lower level of the patella can be easily overlooked. Fractures of the upper pole of the patella with separation of the fragments can simulate the torn quadriceps tendon but palpation will readily reveal the proximal fragment.

DIAGNOSIS

There should be no difficulty in diagnosing a ruptured quadriceps tendon, but the diagnosis is all too frequently missed. The diagnosis may not be made until the swelling has gone down, the quadriceps tendon has been drawn proximally and the patella is lying loose in the anterior compartment of the knee. By this time fibrosis and contracture of the quadriceps may be such that a successful outcome is very doubtful or doomed to failure.

Needless to say, one of the prime prerequisites to a successful outcome is not only a well performed operation but also one done as soon after the injury as possible, preferably within the first forty-eight to seventy-two hours.

PROGNOSIS

It is axiomatic that the earlier a ruptured quadriceps tendon is diagnosed and repaired, the better the end results will be.

Atrophy and fibrosis of the quadriceps muscle takes place at a surprising rate. The atrophy may never be overcome, and the fibrosis not only weakens the quadriceps extension power but also restricts acute flexion of the knee, sometimes to a degree that it interferes with useful function.

If, after the wound has healed, the patient is permitted to be up and about with a cylinder cast, the muscle tone of the thigh will remain surprisingly good in spite of the fact that the knee is held straight by the cast.

With the exception of surgical infection, the outlook in these cases is good to excellent. Younger people make a more rapid and complete recovery than do older people. Patients operated upon early do better than those operated upon late. Skillfully operated cases

with anatomical reapposition, fascial reenforcement and the approximation maintained with the Bunnell pull-out wires do better than those with reapposition of the torn tendon with catgut alone and postoperative cast immobilization.

The average healthy middle-aged patient should make a very good recovery and return to his occupation, regardless of how heavy it may be, within three or four months. Older people in the sixth and seventh decades with degenerative changes of the tendon may take four to five months to return to moderate activities.

Maximum return of function may take six to nine months from the date of surgery.

Especially in this type of case, a cooperative, willing and intelligent patient will do infinitely better than a diametrically opposed type of person.

TREATMENT

Not all cases of ruptured quadriceps tendon require surgery. Some of these cases have only a partial tear, associated with local tenderness, and hematoma formation, but have maintenance of active muscular extension of the knee. In some cases this may be complete; in others a few degrees of extension may be lacking. It is my belief that these cases should be treated conservatively using a cylinder cast from just above the ankle to the groin with the knee in complete extension. Immobilization of this type should last about five to six weeks depending on the merits of the case. This can be followed by physical therapy in the form of heat, massage, active and passive motions, and active and stationary bicycling.

All cases which have lost the voluntary extension power of the knee because of complete tear of the tendon need surgical correction. The sooner this is done the better will be the end results because of less atrophy, muscular fibrosis and retraction of the proximal end of the tendon.

In reviewing the literature a number of proposed methods have been presented. To mention a few: suturing of the tendon with catgut alone, Goldenberg [*7*]; suturing with catgut and silver wire, McBurney [*13*]; suturing with silk, Steiner and Palmer [*18*], Hanlon [*9*], Wetzler and Merkow [*20*]; kangaroo tendon, Conwell and Alldredge [*5*]; quadriceplasty with insertion of the tendon into a bony trough of the patella, Michele and Kreuger [*15*]; Tendinous strips from the vastus medialis and vastus lateralis to reenforce a free tubular fascia lata graft for old quadriceps tear with wide separation, Buttner [*3*]; free fascial grafts and strips, Milch [*16*], Gallie and Lemesurier [*6*].

By necessity, various combinations of these methods have been used by all men who have operated upon these types of cases.

Since 1949 I have been using the following technic for the repair of fresh ruptures of the quadriceps tendon. This method has given earliest recovery and better end results than the various methods I previously tried. From a physiological standpoint it increases the tendon volume in the weakened area, and from a mechanical standpoint it is better as it uses removable stainless steel wire for fixation during the healing period.

The day before surgery the leg is given a surgical preparation from the groin down to the toes. The leg is carefully shaved, washed for ten minutes with soap and water, then alcohol, and dried with ether. Sterile towels or a sterile sheet is now used to cover the prepared extremity and an elastic bandage is used to hold it firmly in place.

At the time of surgery the leg is elevated and a Martin constrictor is applied as high on the thigh as possible, so as not to bind down the quadriceps muscle and interfere with the excursion of the torn end. A pneumatic constrictor can be used equally as well. The field is now washed with hexachlorophene for five minutes, and painted with merthiolate® or mercresin® from the edge of the constrictor to the middle of the lower leg. The leg is now draped so that the patellar area is exposed for about 8 inches above and below the patella. (Fig. 4A.)

An 8 inch midline, longitudinal incision is made and the torn tendon exposed. (Fig. 4B.) The large intra-articular hematoma is evacuated and the joint and tendon are carefully inspected. The tendon is now drawn down with two sharp retractors and sewn to the distal portion of the tear with doubled No. 00 chromic catgut. A slight overlap is preferred in order to get the tendon edges firmly together (Fig. 4C) because as a rule some fraying of the torn tendon edges exists. Parts which are badly frayed are cut off far enough to reach solid tendinous material.

As a rule five or six interrupted catgut

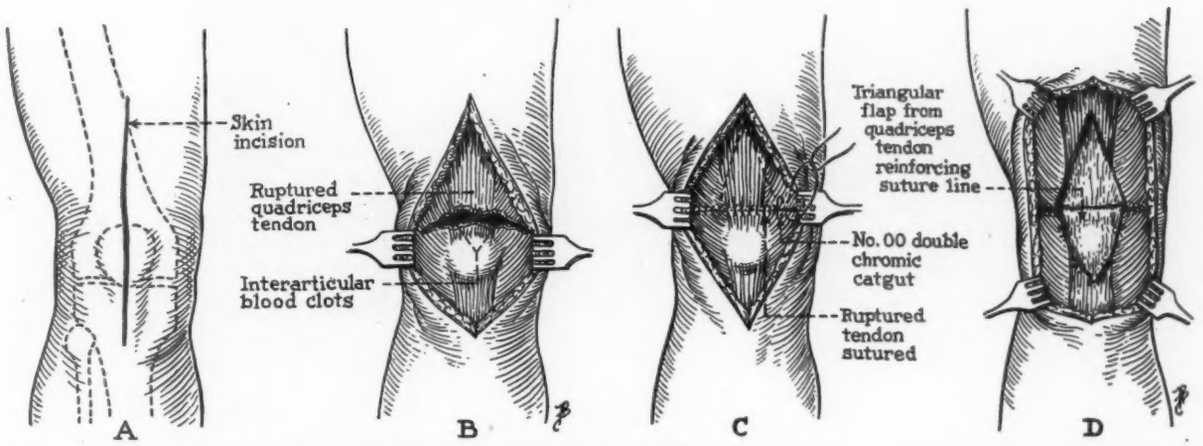

FIG. 4A–D. A, extent of incision to expose the pathologic condition and permit adequate space for the subsequent placing of the Bunnell pull-out wires. B, the usual type of tear of the quadriceps tendon extending laterally and medially up to 2.5 cm. to each side of the patella. C, the torn quadriceps tendon has been sutured with No. 00 double chromic catgut. Interrupted sutures are preferred. D, the triangular flap of the quadriceps tendon sutured over the torn area reenforcing this region. Only about one-third of the quadriceps thickness is utilized. A thicker flap would weaken the tendon proper.

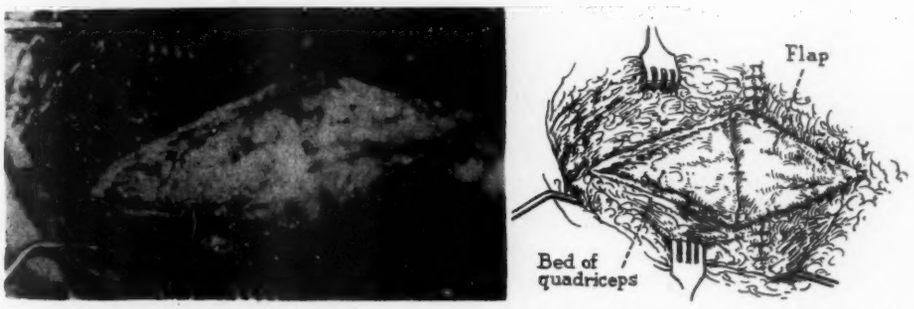

FIG. 4D1. Shows the triangular flap turned down in a recently operated case (June, 1955). This gives excellent suture line reenforcement with living tissue.

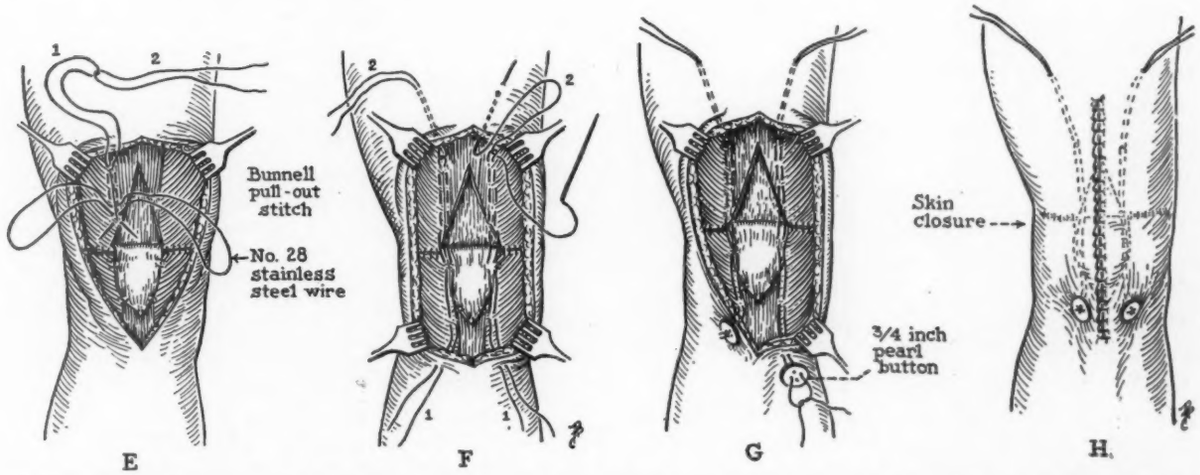

FIG. 4E–H. E, placement of first Bunnell pull-out wire using No. 28 stainless steel wire. F, the two Bunnell pull-out stitches have been placed and the final relationship of the wires to the triangular quadriceps flap is shown. G, the pearl-buttons are placed over the distal wire ends. In order to prevent possible skin necrosis, a few layers of gauze are placed under each button. H, the skin is closed and the relationship of the wires to the underlying sutures and skin closure are diagrammatically shown.

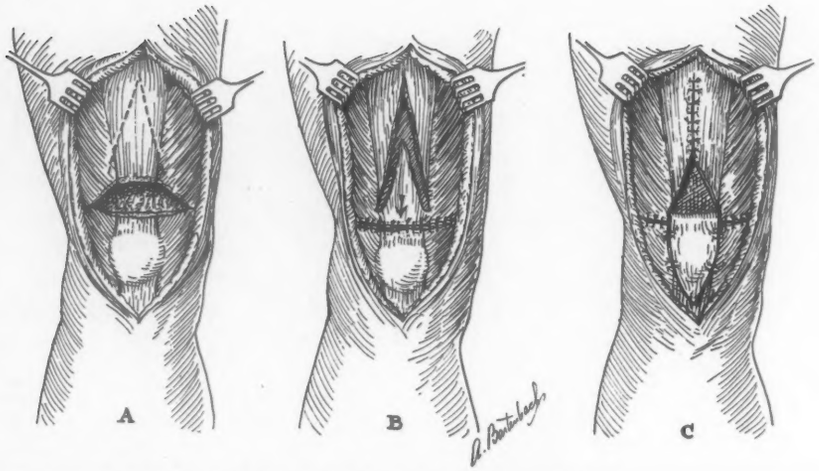

FIG. 5. Codivilla tendon lengthening. A, in old quadriceps tears, retraction and fibrosis prevents apposition of the ruptured surfaces. In order to approximate them an inverted "V" cut of the quadriceps tendon is made and the torn edges sutured. B, the culmination of this procedure. C, the anterior one-third of this triangular flap turned down to reenforce the suture line (as shown in Figure 4D) for the repair of fresh cases. (From: SCUDERI, C. and SCHREY, E. L. Ruptures of quadriceps tendon; study of 14 tendon ruptures. *Arch. Surg.*, 61: 42–54, 1950.)

sutures will bring and hold the torn ends in firm approximation.

Since 1949 I have been using a triangular flap of the anterior portion of the distal end of the quadriceps tendon to fold over the suture line for added tissue reenforcement (Figs. 4D and $4D_1$). This tissue is very strong and when final healing takes place, adds living tendon to reenforce the weakened area. An isosceles triangular flap can be easily turned down about 3 inches along each side and about 2 inches at its base. Thicknesses about $\frac{3}{32}$ to $\frac{1}{8}$ inch can be obtained without materially weakening the remainder of the tendon. This is sutured in place with interrupted double No. 00 chromic catgut.

All interrupted sutures of the tendon and triangular tendinous flap are placed in an X manner. This suture takes massive bites of the tendon and when drawn snugly exerts a compression pressure of the longitudinal tendon fibers and does not tend to pull out, as do the usual parallel mattress type sutures.

Two Bunnell [2] pull-out wires, No. 28 stainless steel sutures are now inserted on each side of the midline at about the lateral and medial borders of the patella. (Figs. 4E and 4F.) The distal ends of the wires are tied over 1 inch pearl buttons (Fig. 4G), the undersurface of which is covered with gauze to prevent pressure necrosis of the underlying skin.

The fascia and subcutaneous tissues are sewn together with single No. 000 chromic catgut, and silk is used for skin closure. (Fig. 4H.)

A cylinder cast is applied from the groin to the ankle with the knee in complete extension.

At the end of ten to fourteen days the sutures are removed and a new cast applied. At this time the patient is permitted to be up on crutches with increased weight bearing on the operated leg.

At the end of six weeks the cast is removed and left off, and the Bunnell pull-out sutures are removed. Active use of the leg is recommended, and physical therapy in the form of heat, whirlpool, massage and bicycling exercises instituted.

The patient will require the assistance of crutches until he regains muscle power and confidence, which may take two to four weeks depending upon the patient.

In cases seen late, fibrosis and retraction of the quadriceps muscle frequently make it impossible to approximate the tendon edges. Here the Codivilla or Bennett quadriceps tendon lengthening is necessary. (Figs. 5A and 5B.) The triangular flap of the anterior portion of the tendon can still be turned down

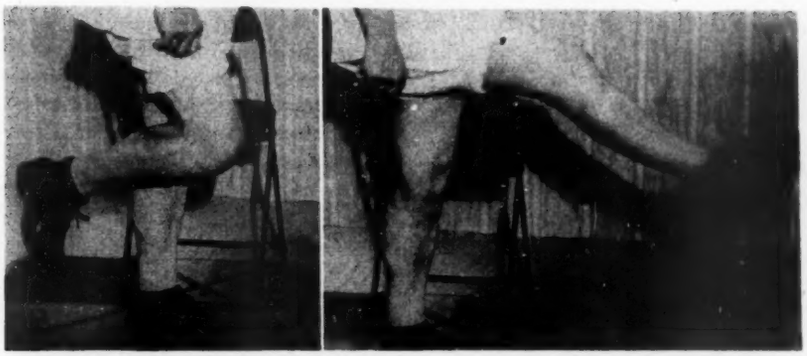

FIG. 6. The end result of a sixty-four year old patient, eight months after surgery. He regained full range of extension but had some residual loss of flexion. The quadriceps muscle power recovery was excellent. The causative etiology was a fall down some stairs which tore the quadriceps tendon. This tendon showed degenerative changes and predisposed the tear.

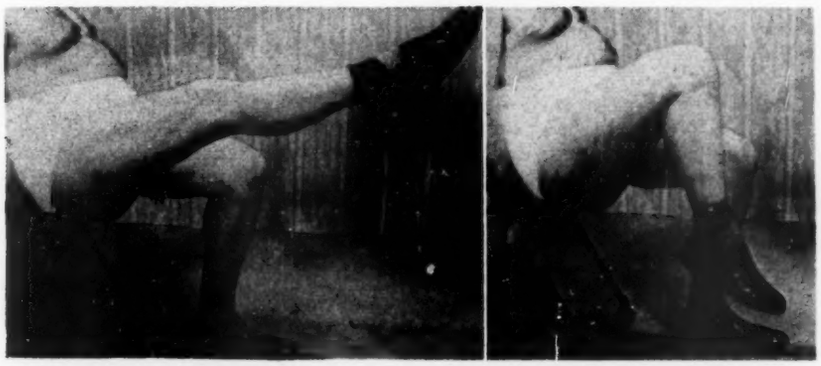

FIG. 7. The ranges of motion in flexion and extension four months after surgery in a forty-one year old man. He sustained the quadriceps tendon rupture when he stumbled down a few stairs.

over the suture line for tissue reenforcement of the area. (Fig. 5C.) The remainder of the surgical correction is the same.

Bennett [1], in 1922, published an excellent article on a type of quadriceps tendon lengthening to regain knee flexion in cases resulting from fibrosis of the quadriceps extension mechanism.

Figure 6 shows the flexion and extension range eight months postoperatively in a short, obese sixty-four year old patient. This tendon showed degenerative changes and predisposed a tear when he tripped while going downstairs.

Figure 7 illustrates the postoperative ranges of motion in a forty-one year old overweight man, whose chronological age was ten to fifteen years older. The microscopic sections of his tendon are shown in Figures 1 and 2. He sustained this injury when he stumbled down a few stairs.

CONCLUSIONS

1. Ruptures of the quadriceps tendon occur in older people with relatively less trauma because of degenerative changes of the tendon proper reducing its tensile strength. This probably accounts for bilateral tendon ruptures in two patients in this series in the older age group (sixty-eight and seventy years of age).

2. In the younger age group a considerable violence is necessary to tear the tendon, the probable mechanism of which is described under etiology.

3. Early and careful surgical repair is definitely indicated when the tear is complete with loss of voluntary extension of the knee.

4. Reenforcement of the suture line with a triangular flap turned down from the quadriceps tendon gives living tissue reenforcement and a better end result than other methods I

have tried, because of the increased tendon volume at the suture line.

5. Bunnell pull-out wires are valuable adjuncts in holding the sutured area together during the six-week healing period.

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DISCUSSION

Homer H. Stryker (Kalamazoo, Mich.): We have had two cases of acute traumatic rupture of the quadriceps just above the patella and one of the infrapatellar tendon in which early operative repair was carried out. Two were injured in falls and the third in an auto accident. In all, voluntary extension of the knee against gravity was lost. All were repaired by simple suture of the ruptured tendons without turning the extra flap of tendon back over the patella as described and illustrated by Dr. Scuderi. All made good recoveries with full return of function. I think the "flap technic" would be especially useful in cases in which the quadriceps is avulsed from the bone, leaving little attached tendon for suture.

Our fourth case was a patient with bilateral quadriceps rupture, first seen five years after injury. He injured one in a fall on icy steps and two months later injured the other in a similar accident.

This presented a different problem. He had no active extension of the knees, had been walking with "back knees" for five years, unable to climb or go down stairs unaided, and had had many spills; severe quadriceps atrophy had developed.

At operation there were 4 inches' separation between the quadriceps tendon and the patella. Repair was accomplished by passing several strips of fascia through a transverse ¼ inch drill hole through the upper pole of the patella and imbricating the ends through the proximal end of the ruptured tendon which could be brought down nearly to the patella—the strips of fascia lata bridging the gap.

Return of quadriceps power and knee motion was slow, but steady, with good functional return in six months. Examination in October, 1957, twelve years after repair, showed practically normal function.

Joseph E. Hamilton (Louisville, Ky.): Being a general surgeon, it is with some trepidation that I discuss the paper by Dr. Scuderi. I do so because of a recent case we had in which the diagnosis was in question at first. It was a sixty-two year old farmer who, two months before while lifting a heavy gate to let the cow into the pasture, had noted what he termed a painful lump that suddenly popped up in the left thigh. He did not seek medical advice until he came to us. Examination revealed merely an 8½ by 6½ cm. mass in the middle third of the anterior aspect of the left thigh. There was no ecchymosis of the skin but direct questioning brought out that he did think he recalled some "bruising" around the site of the lump two months previously. We felt that he probably had a partial rupture of the quadriceps, and sent him home for a month for later re-evaluation. He came back and still had pain. Our orthopedic consultants felt he might have a sarcoma or fibroma in that area. We felt obliged to perform exploration.

On exploration through a vertical incision, such as Dr. Scuderi used, we found a bunched-up mass. There was some white, gritty tissue in the area,

and even at that time the diagnosis was not completely evident. However, there was no hematoma. On further dissection we found that this mass was the ruptured tendon and muscle of the rectus. It had curled under like a fist and caused a tumor which we excised with complete alleviation of the patient's symptoms.

Interestingly enough, the biopsy sent to the Armed Forces Institute of Pathology in Washington has caused some confusion. They pointed out a degenerative process with lymphocytic infiltration which would fit in with the pathological picture just presented.

T. Campbell Thompson (New York, N. Y.): I want to congratulate Dr. Scudari and tell him that I agree very heartily with this treatment.

I would like to ask one question about his pull-out wire sutures which I think are a very fine adjunct. In a strong tendon like this, these sutures sometimes would cause some skin pressure where the buttons are. I think that can be obviated very readily if you use a plaster cast. You can pull the wire through the plaster and put the buttons outside the plaster instead of on the skin. I would like to know whether he puts the suture in the muscle or tendon. On the diagram it appears to be in the quadriceps—a muscle rather than a tendon. As in Dr. Hampton's case, the rupture could occur in the tendon or one of the four parts of the muscle. If the tendon is intact, and we frequently see a rupture of one of the four bellies of the quadriceps, I do not think there is any need for repair.

In this case, Dr. Hampton mentioned the rectus tendon, which is really the only part of the tendon that was involved. Apparently, the man had good function. There is a difference between that and a rupture of the patellar tendon where the rupture is partially in muscle and partially tendon. In our quadriceps plaster operations, we have had one postoperative rupture of the rectus, which is the only part left, and that had to be repaired. I was afraid we would have more such cases, but we only had one.

Dr. Dickison (Montreal, Can.): The obligation of the operation has been doubtful in my mind since I observed two cases ten years ago when I was working for Dr. Harris in Toronto. We had two patients admitted with this condition. One man had much disability, pain and limitation of extension of his knee. The other man had the same diagnosis, which was established, but had no disability and no pain. The answer is that the second man was a Chinaman who had diabetes.

Dr. Ehalt (Gratz, Austria): I liked Dr. Scuderi's paper very much because he demonstrated a different method to suture these ruptures. We suture them together with silk, put on a plaster cast and let the patients walk ten days after surgery. We keep the plaster cast on for six weeks, then take it off and see how the treatment is progressing. So far, we have had very satisfactory results. Consequently, it was interesting for me to hear of different technics.

I would like to mention a case, and ask Dr. Scuderi if he has ever seen a similar one. The patient was a fifty-four year old man who had a complete rupture of the tendon on exercise of the patella. This was very difficult to correct. I had to cut off a bit of the base of the patella, get some fresh bone formation there and affix the tendon to this fresh bone with stainless steel. We did not use a pull-out suture, but affixed the tendon to the base of the patella. Normal function was obtained.

I found this one case very unusual; my former teacher also had one case.

Carlo Scuderi (closing): Dr. Stack asked me if we used the pneumatic cuff. All of these cases are treated with a constrictor. The pneumatic cuff can be used satisfactorily. We still use the Martin constrictor as far up on the groin as possible, so we do not bind down the quadriceps mechanism.

The question that Dr. Ehalt brought out about rupture at the bone attachment is good. I have had no such experience. If it does occur, it stands to reason that the thing you want to do is freshen up the bone, reattach it and hold it in place by some form of stainless steel fixation.

Dr. Thompson asked the question of where we place the wire. You cannot put the wire in the muscle texture because it will tear out very rapidly. You must get it into the tendinous portion of the extensor mechanism.

One must not get too enthusiastic about moving these patients too early. It was shown a good many years ago by Mason and Koch that early motion of repaired tendons produces fibrosis. It does not increase the motion of that joint. The same thing happens here. Some doctors are absolutely in favor of starting these patients walking as soon as they wake up from the anesthesia, but if they are kept in bed a little longer, it will not hurt them. If ambulation is started early, irritation and a fibrotic mass result. You destroy what you are trying to accomplish. Do not start mobilization too early.

Dr. Thompson brought out another point. You must protect the skin from the pressure of the buttons in all of the cases. Before we pull down the wire over the buttons, we put in five or six layers of gauze or sterilized sponge rubber because if you do not, necrosis may develop under the button. We have had no difficulty in doing this.

Regarding his point about bringing the wires to the outside of the cast, there is atrophy of the thigh and atrophy about some of the tissues about the knee when the swelling goes down. It thereby tends to relax the wire tension, and is not as efficient as the method described. I have never done this, but I think you have greater control of the tension of the wire if you fix it as close to the skin and underlying bone as you possibly can.

Hypermobility of the Cervical Spine in Children: A Pitfall in the Diagnosis of Cervical Dislocation

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Subluxation of the cervical vertebrae without associated fracture is encountered frequently by the orthopedic surgeon. This injury has been described in the literature many times, and three types are recognized.

Most often seen in children is spontaneous atlantoaxial dislocation which, according to Werne [6], was first described by Bell in 1830. Although the exact pathogenesis is still controversial, the most widely accepted explanation is that hyperemic decalcification of the upper cervical vertebrae allows loosening of the atlantoaxial ligaments, all of which supposedly is induced by an associated infection of the upper part of the respiratory tract, such as tonsillitis.

A second type of dislocation without associated fracture is rotary suboccipital dislocation characterized by partial disengagement of one of the condyles of the occiput and its corresponding atlantal facet. The child afflicted with this injury presents himself with torticollis that may or may not have been preceded by trivial trauma. Unless special attention is called to the occipitoatlantal articulations, the condition is passed over as "wryneck" or "myositis," and reduction of the dislocation occurs spontaneously.

The third commonly encountered dislocation of the neck without associated fracture is the unilateral subluxation of the cervical vertebrae below the second vertebra so well described by Stimson and Swenson [4] in 1935. These authors reported on sixty-six patients treated over a four-year period and stressed the importance of lateral stereograms of the spinal column in demonstrating the unilateral forward subluxation of the inferior on the superior cervical facets.

We wish to call attention to a fourth type of cervical "dislocation" not associated with fracture. This is the apparent subluxation of the second or the third cervical vertebra on the subjacent vertebra seen frequently in children and noted only on lateral roentgenograms taken with the neck in flexion. Properly speaking, this is not a bona-fide dislocation and should be recognized for what it is, namely, hypermobility of the articulations between the second and third or the third and fourth cervical vertebrae, which is a normal variation in many children. The only justification for referring to this variant as a "dislocation" is our presumption that many otherwise normal necks have been unnecessarily braced or placed in traction for prolonged periods under the misconception that serious injury existed.

GENERAL BACKGROUND

This concept is by no means new. Several authors have observed hypermobility of the second cervical vertebra. Bailey [1], in his discussion of the normal variations in the cervical portion of the spinal column in children, wrote, "In lateral roentgenograms of the cervical spine in adults, with the head held in mild flexion, some 'step-off' is normally seen, i.e., the body of each vertebra is displaced slightly anteriorly with respect to the subjacent one. Infants and children show the same normal finding when the neck is held in mild flexion, especially at the level of the second and third

cervical vertebra, where there may be a step-off of as much as 2 to 3 mm."

Townsend and Rowe [5] reported subluxation of the second cervical vertebra in four children whose ages ranged from three and a half to six years. Each patient complained of a stiff, painful neck after an upper respiratory infection. All were relieved of symptoms after treatment by means of cervical traction; however, the subluxation persisted. These authors were able to find a report of one similar case in the literature. They were of the opinion that subluxation of the second on the third cervical vertebra was a normal variation in the degree of vertebral mobility and confirmed this impression by roentgenographic study of children ranging from ten months to thirteen years of age. However, they did not state the number of children examined nor the number of patients whose roentgenograms demonstrated subluxation. They concluded that, in general, the longer the neck and the younger the person, the greater is the degree of mobility of the second on the third cervical vertebra. Adult standards of response were attained by eight years of age in most of their cases. They indicated that spasm of the prevertebral muscles secondary to an upper respiratory infection caused loss of the normal cervical lordosis and acute flexion of the upper cervical vertebra.

All authors writing on traumatic dislocation of the cervical vertebrae not associated with fracture have noted the frequency of dislocation at the level of the second cervical vertebra. Of Stimson and Swenson's sixty-six patients, thirty-seven sustained dislocation between the second and third cervical vertebrae. Donaldson [2] reported that 75 per cent of the subluxations in his group occurred at this level.

The explanation given for the frequency of dislocation between the second and third cervical vertebrae is based on anatomic considerations. First, the bodies of the upper cervical vertebrae, in contrast to other portions of the spinal column, are wedged anteriorly (Fig. 1), thus allowing a greater degree of forward glide when the neck is flexed. The second consideration is the position of the facets in relationship to the intercorporeal joint. In the cephalad direction, the facets become more and more horizontal as seen on the lateral roentgenogram. (Fig. 1.) Roberts [3] has offered these observations as explanation for the fact that subluxation is more common in the first, second and third cervical vertebrae, whereas fractures occur more frequently in the lower vertebrae.

FIG. 1. Lateral roentgenogram in a four year old boy showing apparent subluxation of second cervical vertebra. Note wedging of bodies of cervical vertebrae and the more horizontal position of facets in the upper vertebrae.

It is sometimes difficult to distinguish hypermobility with apparent subluxation from actual subluxation in a child who has sustained an injury. The following cases illustrate the problem.

CASE REPORTS

CASE 1. A four year old white boy was referred to the Mayo Clinic because of an audible "popping" in the cervical portion of the spinal column. This sound was noted only on extreme flexion or extension. No injury had occurred. The range of motion was normal and painless. A lateral roentgenogram taken in August, 1955, demonstrated apparent anterior displacement of the second cervical vertebra. (Fig. 2*a*.) Use of a cervical brace was recommended and it was worn until July, 1956. After removal of the brace the patient resumed his normal activities and has experienced no further difficulty. A lateral roentgenogram made in August, 1957, demonstrated persistent hypermobility of the second cervical vertebra. (Fig. 2*b*.)

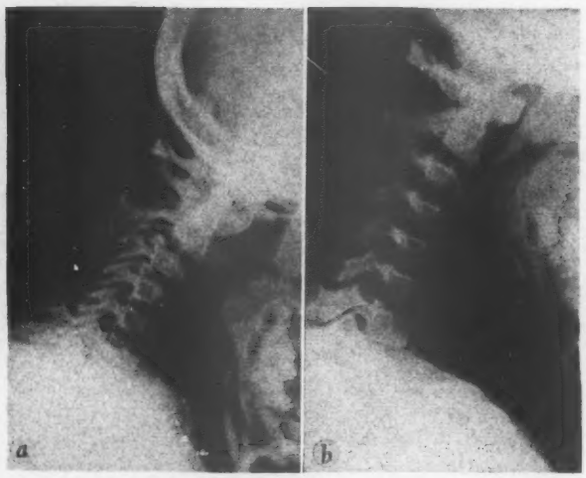

FIG. 2. Lateral roentgenograms in a four year old boy. (*a*) Appearance in August, 1955, interpreted as showing subluxation of the second cervical vertebra. (*b*) Appearance in August, 1957, demonstrating persistent hypermobility of the second cervical vertebra.

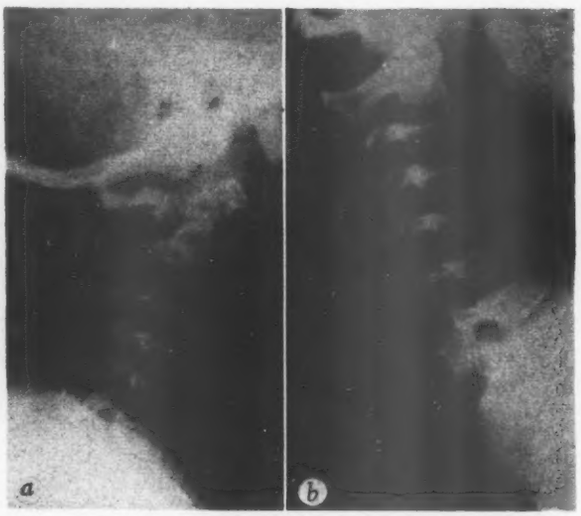

FIG. 3. Lateral roentgenograms in a four year old girl. (*a*) Appearance in April, 1956, interpreted as showing subluxation of the second cervical vertebra on the third. (*b*) Appearance in August, 1957, demonstrating persistent apparent subluxation of the second cervical vertebra.

CASE II. A four year old white girl noted sudden onset of pain in the neck while bending over her doll buggy. She cried with pain and told her mother that she could not move her neck. The mother stated that the child had experienced frequent colds and upper respiratory infections; however, she had been well during the week before admission. Examination revealed an apprehensive child who refused to move her neck for fear of pain. Torticollis and muscular spasm were absent. A lateral roentgenogram taken in April, 1956, was interpreted as showing forward subluxation of the second cervical vertebra. (Fig. 3*a*.) The child was kept in the hospital for halter traction and observation. Within twenty-four hours she was completely free of pain. Motion was not tested until the third day, when a full range of painless motion was evident. However, use of a cervical collar was recommended and it was worn until July, 1956. When last examined, in August, 1957, she was completely free of symptoms, yet a lateral roentgenogram at this time made with the head in flexion revealed persistent apparent subluxation of the second cervical vertebra. (Fig. 3*b*.)

CASE III. A twelve year old boy fell off a sled and struck his head against the axle of a truck in November, 1956. He remained unconscious for approximately fifteen minutes and was drowsy and confused for about one hour. When he arrived at the hospital two hours later, he was alert and cooperative. Neurologic examination showed nothing abnormal. Fresh blood was present in the left auditory meatus. Roentgenograms of the skull were normal but the presence of a basilar skull fracture was suspected. There was no pain in the neck. However, a routine roentgenogram was interpreted as showing subluxation of the second cervical vertebra. (Fig. 4*a*.) For this reason, Crutchfield's tongs were inserted and 8 pounds of traction were applied to the skull. A plaster of paris Minerva jacket was applied on November 11, 1956. This was removed on February 6, 1957, being replaced with a cervical brace that was worn until April 15, 1957, approximately six months from the time of injury. The patient was last examined in July, 1957, at which time he was well and had no complaints referable to the neck. A roentgenogram made at that time revealed persistence of the apparent subluxation of the second cervical vertebra. (Fig. 4*b*.)

CASE IV. A sixteen month old boy fell from a second story window on May 7, 1957, and landed on a cement sidewalk. Examination of the child when he arrived at the hospital an hour later revealed contusions and abrasions of the left side of the head and shoulder. Full and painless motion of the neck was present. A lateral roentgenogram was interpreted as showing subluxation of the second cervical vertebra. (Fig. 5*a*.) The child remained in the hospital for twenty-four hours for observation. No other treatment was recommended. When the patient was last examined in August, 1957, there were no complaints referable to the neck and the roentgenogram revealed persistence of the apparent subluxation at the second cervical vertebra. (Fig. 5*b*.)

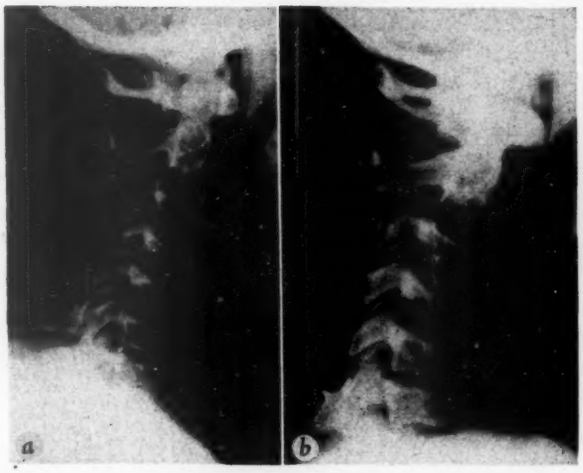

FIG. 4. Lateral roentgenograms in a twelve year old boy. (*a*) Appearance in November, 1956, interpreted as showing subluxation of the second cervical vertebra. (*b*) Appearance in July, 1957, following immobilization of the neck for six months. Note the persistent apparent subluxation of the second cervical vertebra on the third, which is a normal range of motion for this patient.

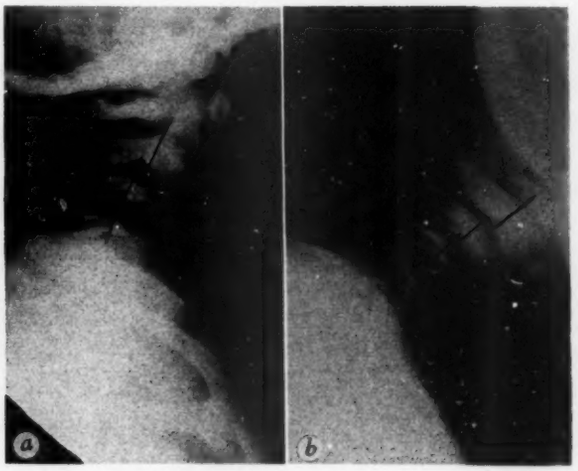

FIG. 5. Lateral roentgenograms in a sixteen month old boy. (*a*) Appearance in May, 1957, interpreted as showing subluxation of second cervical vertebra. (*b*) Appearance in August, 1957, showing persistent asymptomatic hypermobility of the second cervical vertebra.

COMMENT

The first three of these patients were treated for subluxation of the second cervical vertebra because of a preceding injury or because of symptoms referred to the neck. However, we believe that hypermobility of the spinal column, rather than dislocation, accounted for the roentgenographic appearance of subluxation. In all instances the roentgenograms revealed hypermobility long after the alleged dislocation. None of these patients exhibited the signs of actual unilateral subluxation presented by Stimson and Swenson, including torticollis with the head tilted away from the affected side, muscular spasm and pain on the "long side" of the torticollis, and limitation of lateral flexion toward the affected side. If torticollis, pain or limitation of motion is present in association with a roentgenogram suggesting subluxation, one is obligated to treat the patient with cervical traction or a collar. It is the patient for whom there are only roentgenographic findings who may be erroneously overtreated with a brace or traction.

In order to become acquainted with the normal variations in cervical mobility in children, we obtained roentgenograms from 100 normal children taken at random from those coming for general physical examinations. The ages ranged from two to fourteen years. The group included forty-seven girls and fifty-three boys. Lateral roentgenograms were made with the head held in flexion and in extension. Particular attention was paid to the degree of anterior and posterior glide of one vertebra on another. The "step-off" in flexion was measured in millimeters, using the posterior surface of the centrum as the point of reference.

TABLE 1
AMOUNT OF FORWARD GLIDE AT THE SECOND AND THIRD CERVICAL INTERSPACES IN LATERAL ROENTGENOGRAMS OF 100 NORMAL CHILDREN

Forward Glide (mm.)	No. of Cases at Second Interspace	No. of Cases at Third Interspace
4	9	1
3.5	4	1
3	20	5
2.5	9	8
2	21	33
1.5	8	12
1	22	30
<1	7	10

According to our observations, hypermobility in the anteroposterior plane may occur either between the second and third vertebrae or between the third and fourth vertebrae. In no instance did we note excessive mobility in the vertebrae below the third interspace. Table 1 summarizes the measurements in these 100 children. The greatest excursion at any

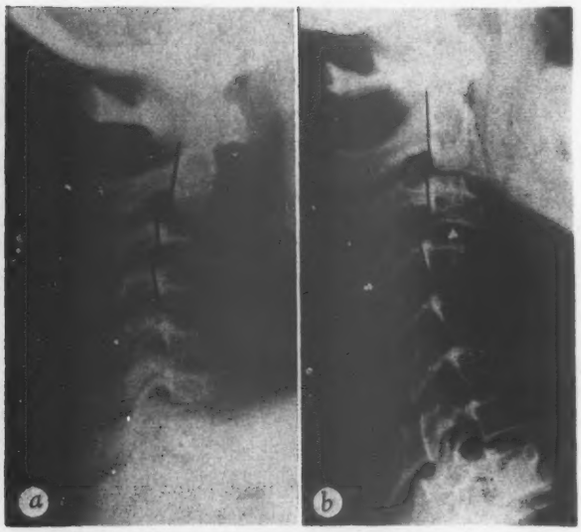

FIG. 6. (*a*) Lateral roentgenogram in a normal three year old girl, showing hypermobility of second cervical vertebra. The 4 mm. "step-off" between the second and third cervical vertebrae might be interpreted erroneously as subluxation. (*b*) Normal five year old girl who had no symptoms referable to the neck. Lateral roentgenogram taken with neck in slight flexion shows a 4 mm. "step-off" between the third and fourth cervical vertebrae.

vertebra was 4 mm., and this was present nine times at the level of the second cervical vertebra (Fig. 6*a*) and only once at the third. (Fig. 6*b*.) It was our impression that the presence of a "step-off" measuring at least 3.5 mm. might lead the unwary roentgenologist or orthopedist to interpret the film as showing a "dislocation." However, fifteen of these children, eight boys and seven girls, demonstrated this degree of mobility, which was at the second cervical vertebra in thirteen instances and at the third in two. Even more children might have demonstrated hypermobility had complete cooperation been obtained from all patients in taking the flexion views.

Thus it is evident that the roentgenogram may be misleading unless results of physical examination confirm the radiologic diagnosis of subluxation at the level of the second and third cervical vertebrae. It is our belief that torticollis, muscular spasm, persistent pain or limitation of motion must be present for confirmation of the radiologist's report. Prolonged traction or immobilization for normal hypermobility of the upper cervical vertebrae in a child is useless overtreatment. However, an even graver error may be committed if genuine cervical dislocation is permitted to go untreated. The physician responsible for the management of such conditions should be informed regarding the normal variations that do occur.

SUMMARY

Subluxation of the cervical vertebrae not associated with fracture occurs frequently in children. Three types are recognized, namely, spontaneous atlantoaxial dislocation, unilateral suboccipital dislocation and rotary unilateral subluxation below the second cervical vertebra. Pain, torticollis, muscular spasm and limitation of motion almost always accompany these types of subluxation.

Hypermobility of the second and third cervical vertebra, or apparent subluxation, also is encountered frequently in children and is a normal variation. In a roentgenographic study, fifteen of 100 normal children had a "step-off" between the second and third or the third and fourth cervical vertebrae of 3.5 or 4 mm.

Unless the roentgenographic interpretation is confirmed by the physical signs of genuine subluxation, overtreatment by means of prolonged traction or immobilization in a cast may be carried out under the misconception that serious injury exists.

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Lesions of the Odontoid and Their Management

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OUR personal confusion in interpreting a large series of consecutive lesions of the odontoid led us to review the subject. The literature and clinical tradition divide treatment into various categories. These include dynamic and static attempts at external fixation, such as traction and bracing. In addition, there is a place for decompression of neural elements and also for fusion.

Technics rather indiscriminately run from fusion of the atlas and axis to inclusion of the occipital bone and even extending the fusion from the occipital bone as far as C4 [*1,2*]. In an attempt to formulate a systematic and logical approach, we have analyzed twenty-two cases at the Columbia-Presbyterian Medical Center, wherever sufficient history, physical examination and x-ray material were available. Our conclusions are based upon this material, although our deductions therefrom are subject to errors of reasoning.

Phylogenetically the atlas and axis are the oldest of all vertebrae and involved in the most ingenious endowments of movement inherent in the skeleton [*3*]. The previous large range of morphological development makes variations or anomalies almost endless in type. Such anomalies would be of mere academic interest to the paleontologist and laboratory anatomist were it not for the fact that they may play a part in the development of acute, progressive, or static pathology involving the dynamics of motion and the central nervous system.

ANATOMICAL CONSIDERATION

On these grounds, we consider it worthwhile reviewing some of the salient anatomical features of the region. The atlas, upon which the head rests and upon whose cojoints the head may elevate or depress, has somewhere in its past ceded its centrum or body to its more caudal partner, the axis. By converting the atlas to a mere ring surrounding the odontoid, nature has added to the fore and aft motion of the head, a pivotal motion allowing fluid rotation. "The dumb man says yes with his occipito-atlantal joints and no with his atlanto-axial joints." The axis of motion and the center of gravity of the skull revolve upon the vertical plane of the odontoid, passing from its apex below the clivus through the anterior portion of the ring of the atlas down to its base in the rather large body of the axis. The chief special ligaments of the area include (Fig. 1) the transverse ligament, an extremely strong band crossing between the tubercles on the inner side of the lateral masses of the atlas and curving posteriorly around the odontoid but separated from it by a synovial cavity. The transverse ligament and its resistance to avulsion are a major key to the various complexities of management of lesions of the odontoid process. The alar, lateral odontoid, or check ligaments are likewise very strong but rather short ligamentous bands attached on either side of the summit of the odontoid process and laterally to the tubercles on the inner side of the condylar portions of the occipital bone. These ligaments define and control rotation of the head. The apical ligament extends upward from the apex of the odontoid to the anterior margin of the foramen magnum. Together, these ligaments, with others, limit the odontoid in its excursion and also surround the odontoid process with a synovial cavity whose extent stretches below its base. At the base there is often a vestigial remnant of intervertebral disc. The lateral joints of the first two cervical vertebrae are designed for motion rather than support and lie roughly in the horizontal plane.

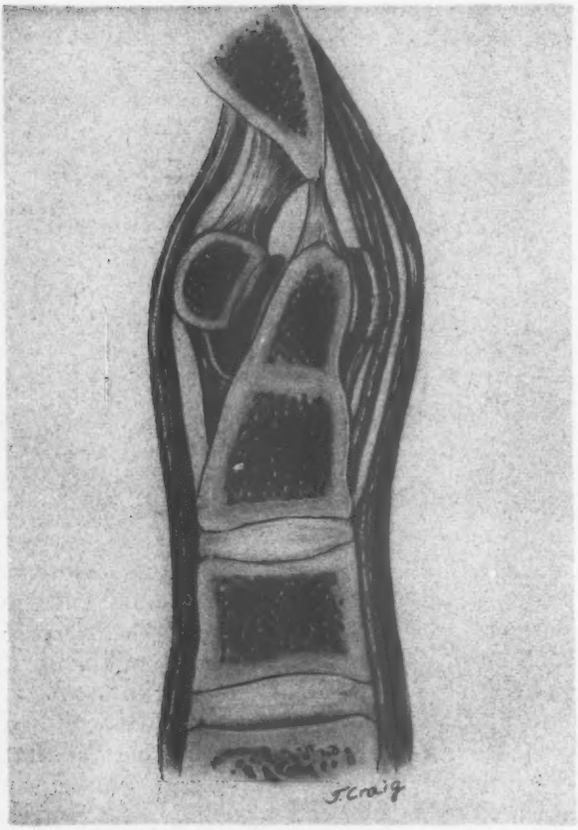


FIG. 1. Sagittal cross section of the upper cervical spine according to Testut. From the anterior to the posterior aspect, the ligaments are: the anterior longitudinal ligament, the atlanto-occipital ligament, the apical ligament, the transverse ligament, the occipitoaxial ligament and the posterior longitudinal ligament. Note that the odontoid process is surrounded by synovial membrane down to its base.

Since the center of gravity and the pivotal forces of motion of the large and heavy head bearing on the spine run through the odontoid process any malalignment of the latter tends to allow the head to move or slide forward since the horizontal nature of the joints afford no anterior buttress to such motion.

TYPES OF LESIONS

With this brief summary of the anatomy and dynamics of the region, we may now turn to a classification of the type of lesion we have met in our survey:

1. Congenital variations of the odontoid process itself: (a) ununited (Fig. 2); (b) excessively hypoplastic ununited odontoid (the latter type may not allow for sufficiently strong check ligaments to control the motion of the odontoid in relation to the atlas);

FIG. 2. Congenital ununited odontoid. The dens is smaller than average. There is a forward position of the atlas on the axis.

(c) ununited odontoid process with fusion of the odontoid to the clivus. (Fig. 3.)

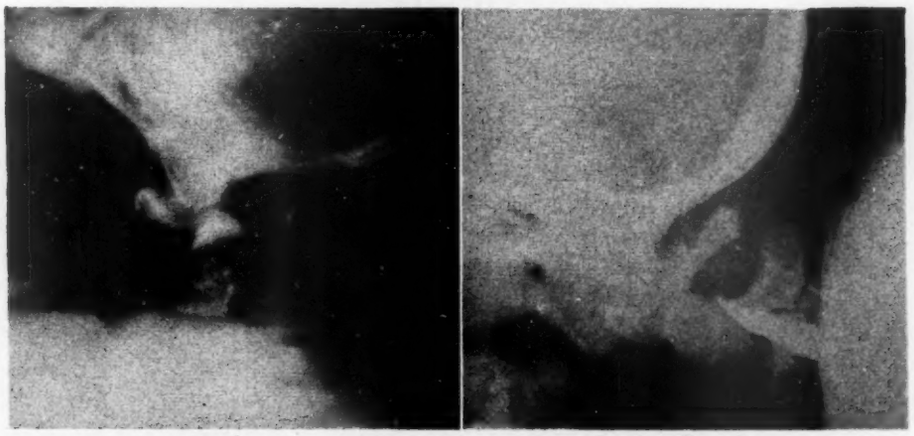
2. The aforementioned variations with or without assimilation of the atlas into the occipital bone.

3. Fractures of the odontoid process at its base. (Fig. 4.) A subgroup here includes the old or childhood fractures with lack of fusion of the base of the odontoid. These are often impossible to distinguish from congenital lesions.

4. Fractures of the odontoid below the base or in the body of the axis. (Fig. 5.)

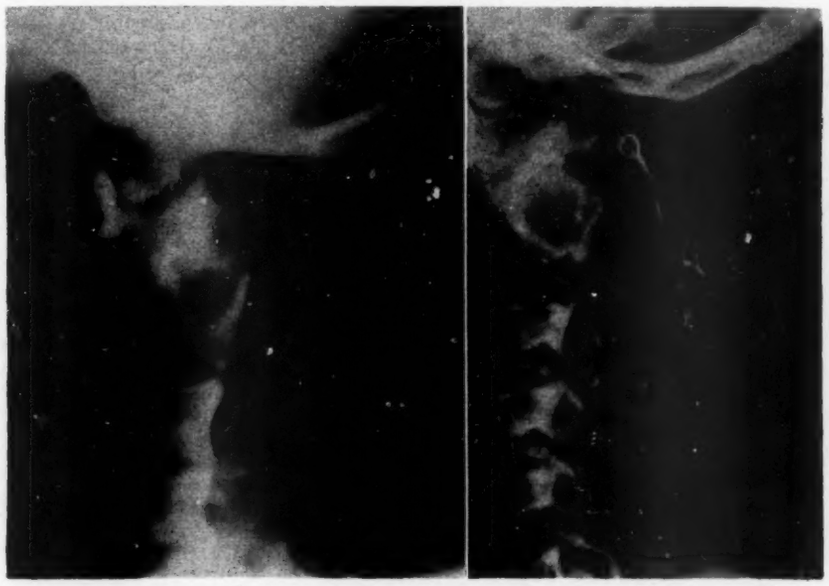
5. Chronic atlantoaxial dislocation due to relaxation and/or degeneration of the ligamentous attachments with forward progression of the head and the atlas on the axis: (a) the former plus evidence of trauma.

It should be noted that all these may be static lesions without evidence of progression, acute lesions such as after trauma, or progressive lesions obviously superimposed on prior abnormalities. Long-term physiological stress creating ligamentous degeneration engrafted on static anomaly may create the clinical picture at the time that signs and symptoms become noteworthy. (Fig. 6.) Trauma to the region may be the sole cause of pathology or merely a precipitating agent. Thirdly, long-standing cervical arthritis with loss of mobility below may create a fulcrum at the anomalous



3A 3B

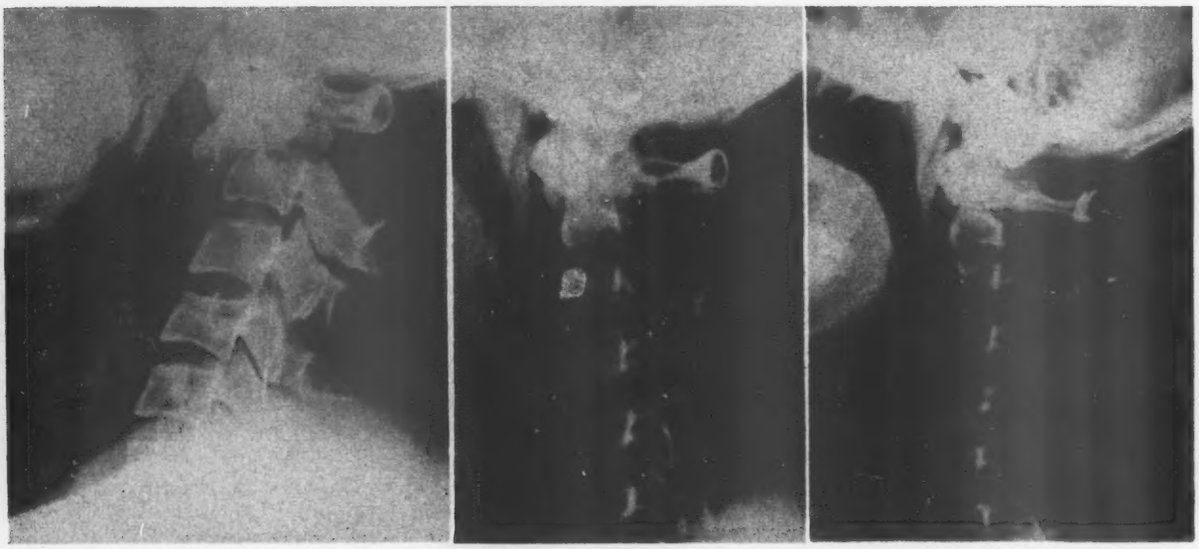
FIG. 3. A, congenital failure of fusion of the odontoid to the body of the second cervical vertebra in a five year old girl. The odontoid is fused to the clivus. B, prone lateral view made during cervical myelography, with the head extended and the chin resting on a small pillow, showing complete disappearance of the displacement.



4A 4B

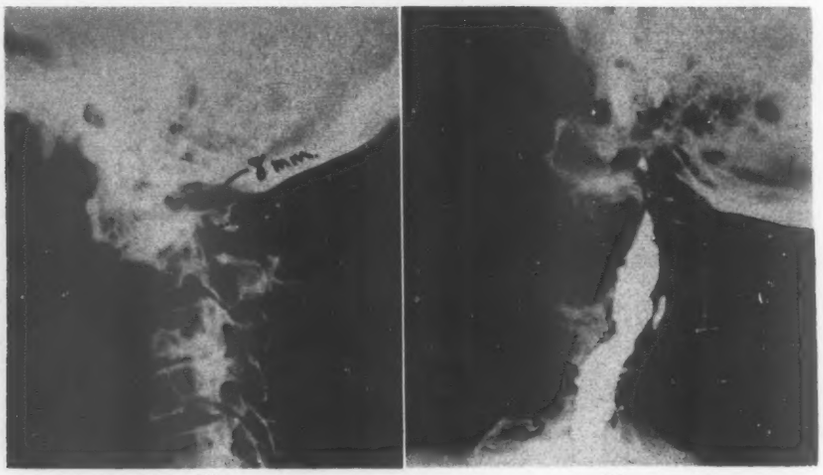
FIG. 4. A, laminagram of the upper cervical region demonstrating a fracture across the lower end of the odontoid process with typical forward displacement. B, a lateral view made following attempt at wiring reveals the ineffectiveness of the wires.

C1-Z level and be a precipitating factor in the rapid advance of previously only potential pathology. Occasionally, unrecognized dislocation and/or fracture may heal by scarring and fibrous union. Gradual attenuation of ligamentous strength and, perhaps, further insults over a long period may give rise to what seems to be a paradoxical response to a very mild subsequent trauma. This type of case has strong medicolegal implications. On occasion, prevertebral infections may lead to attenuation of the ligaments and osteoporosis of the bony support with spontaneous dislocation. This entity has been well described. Nonetheless, one must note the frequent innocuousness of some anomalies and also of fracture and fracture-dislocations, even while pointing out the effect of subsequent traumas in the development of overt clinical syndromes. (Fig. 7.) Any x-ray department may turn



5A 5B 5C

FIG. 5. A, fracture dislocation below the base of the odontoid with forward displacement. Note large prevertebral soft tissue swelling. B, film made a few weeks later showing adequate reduction. At this time it was decided to fuse and wire: this may not have been necessary. C, the end result shows good alignment and successful wiring and grafting.



6A 6B

FIG. 6. A, old fracture of odontoid with forward displacement. There is considerable osteophyte formation here indicating an old lesion. Nevertheless, the clinical symptoms were of relatively recent onset. The picture further emphasizes the fact that cord compression takes place between the posterior arch of the atlas and the posterior aspect of the body of the axis. B, same case. Film made during cervical myelography with the patient in the prone position.

up the most frightful appearing atlantoaxial changes where there is no evidence of appropriate clinical signs; likewise, the autopsy room. John Ashhurst [4] in his most interesting "Injuries of the Spine" of 1867, cites what he calls "Phillips oft quoted case," in which the atlas and odontoid process being broken and thrust forward, the head had settled down and formed a new joint with the axis, the cord being uninjured and the patient dying of other causes. The patient had fallen head foremost from a hay rick. Within two days he had returned to work and after a month walked two miles to consult a surgeon. He complained of stiffness of the neck but was without paralysis. He died a year later of dropsy. At

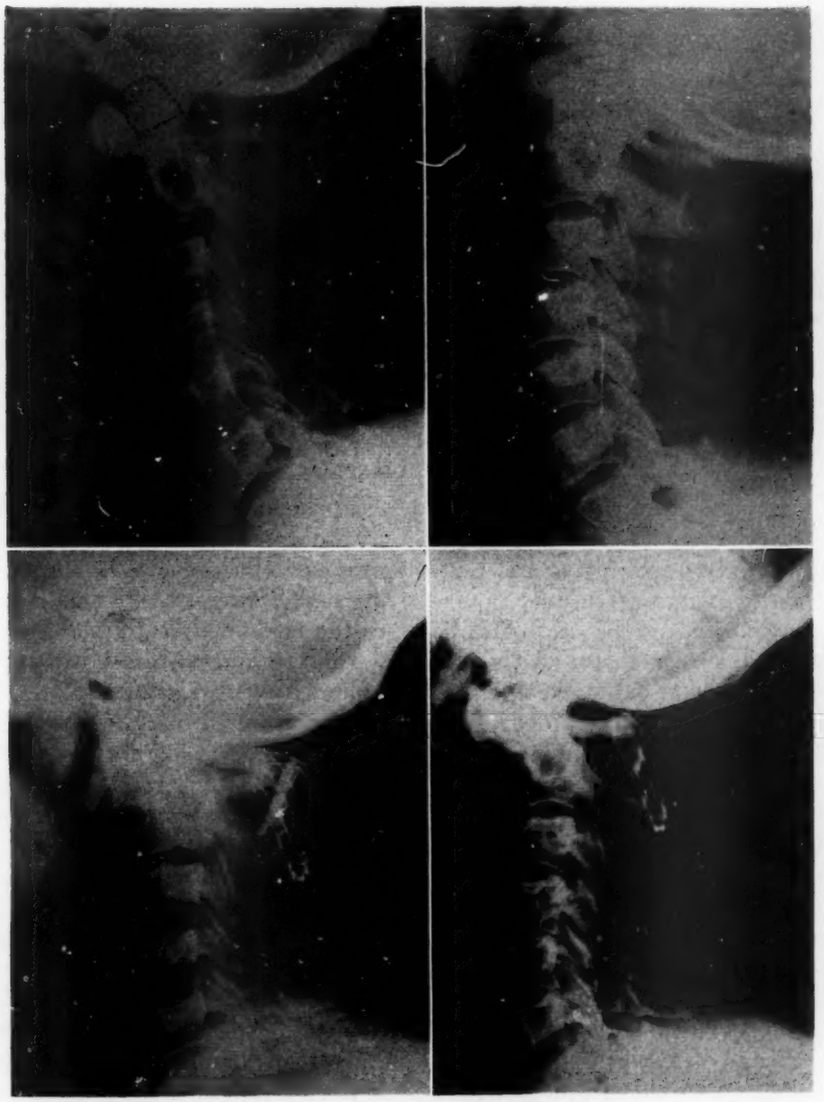


FIG. 7. A, congenital ununited odontoid. This patient had no history of trauma. B, lateral view made with the head in extension revealed complete reduction of the forward displacement of the atlas. An attempt at grafting and wiring was made. C, this film made through a cast shows that the forward displacement persists. D, several months later the graft is almost completely reabsorbed, the wires are loose, the luxation persists. The patient was asymptomatic.

that time an autopsy showed fractures of the atlas and odontoid process which were thrust forward against the pharynx; the head had settled down on the axis to form a new joint. The cord remained uninjured! It may sometimes be unwise to embark on dangerous and time-consuming procedures in which the lesion may be far less malignant than it looks. Yet, mild trauma and sequential changes may play a large part in the appearance of serious compression syndromes. Both points must influence one's thinking in weighing therapy in a given case.

The diagnosis, although not nearly so difficult to derive as in Ashurst's day, when the position held by the head or the noting of an abnormal protuberance were the only diagnostic criteria prior to the ultimate knowledge of the autopsy room, can still be difficult. We have touched on some of the reasons such as the developmental complexity of the region and its ossification centers. In addition, one

is dealing clinically with patients with possible or obvious cord damage so that it is essential to exercise the utmost care in change of position. Diagnosis depends almost completely on definitive radiography. The important views begin with the lateral, which must be true. The anteroposterior view, taken through the open mouth, which has long been a source of fascination or technical pride to the technician, is not nearly so important. Where possible, flexion and extension views will show the presence or absence of movement and its fulcrum. Without laminography, many mistakes in proper analysis of the problem will be made. In static cases, without recent acute trauma, myelography often is of primary importance in clarifying the nature of cord compression.

The position of the patient during the performance of the x-ray examination may determine what one will see in the radiograph. When the x-ray films are taken with the patient prone with the head extended and the chin supported, one may gather deceptive evidence of normal alignment of the upper cervical vertebrae. This is a position which tends to reduce dislocations of atlas on axis. (Fig. 3B.) By the same token, it is an excellent form of attempted reduction. If such a position can be achieved in taking an x-ray, it is certainly a good way to perform reduction of a dislocation. Having repeatedly noted the ease of reduction of some atlantoaxial dislocations in the aforementioned position, we feel it is an ideal means of restoring alignment. If the patient is placed in the prone position in a Stryker or similar frame with the forehead firmly held and the chin-strap used to exert pressure posteriorly, it is often possible to obtain good alignment, check the position radiographically, and then have the patient in a permanent position for operation or the application of an external type of fixation.

Even under the best of conditions, it is sometimes very difficult to analyze the place of trauma versus anomaly in these cases and occasionally ancillary data may be helpful. Statistically, platybasia or basilar impression are very infrequently associated with anomalies of the odontoid [*5*]. This fact might throw some emphasis on trauma in a difficult differential diagnosis. The presence of prevertebral swelling in the early stages is excellent evidence in favor of trauma. (Fig. 5A.) Changes in the posture of the neck such as denote splinting of the erector capitii muscles also suggest a dynamic rather than a static abnormality. However, pain and splinting may be related to simple strain or to injuries lower down in the cervical spine. The history may be helpful in bringing out repeated episodes of lightning paresthesias after mild trauma or episodes of quadriparesis which were so ephemeral that the patient paid little attention to them. This suggests anomalies of the odontoid with relaxation of the ligaments and chronic dislocation.

MANAGEMENT

Focusing one's attention now to management of the given case and taking into account the previous observations, we arrive at the following deductions relating the nature of the entity to the type of therapy:

Atlantoaxial dislocation with integrity of the odontoid-axis relationship. This is actually the most dangerous combination of anatomical circumstances. The atlas may slip forward, and since the integrity of the odontoid is preserved, the cord will be caught between the odontoid ventrally and the posterior elements of the atlas posteriorly. We agree entirely with Watson-Jones' [*6*] statement that, "contrary to opinion generally accepted, dislocation of the atlas alone is much more serious than fracture-dislocation because if the odontoid is intact, the spinal cord is in danger of being crushed against it by the posterior elements." In these cases the proper treatment consists in decompression by removal of the posterior elements of the atlas. Depending upon the relationship of the cervical canal to the occiput it may or may not be necessary to enlarge the foramen magnum posteriorly to improve the cephalad arc of the cervical cord as it enters the skull.

Atlantoaxial dislocation with integrity of the transverse ligament and movement of the odontoid only in relationship with the atlas after fracture of the odontoid at its base. Here the treatment ordinarily need not take into account the relationship of the odontoid process to the ventral aspect of the spinal cord. Accordingly, simple fusion of the first and second cervical vertebrae will suffice. This method of management is far simpler, more likely to succeed, and less of a physical

handicap than the fusion which includes the occiput. Traditionally, this and similar types of fusion have been performed by wrapping wire around the posterior elements of C1 and C2 with or without the previous roughening of the edges or insertion of bone between the adjacent vertebral elements. Study of postoperative x-rays as often as not reveals broken wires. These may or may not be significant in that fusion has or has not taken place. Often x-rays taken very soon postoperatively show the wires have cut through since there is a good deal of stress on them and the posterior elements of the atlas are not particularly strong. Accordingly, we have tried to design a better engineered means of maintaining alignment posteriorly during the period before bony fusion takes place. (Fig. 8.) The only advantage of such an apparatus lies in its stability, diffusion of stress and ease of application.

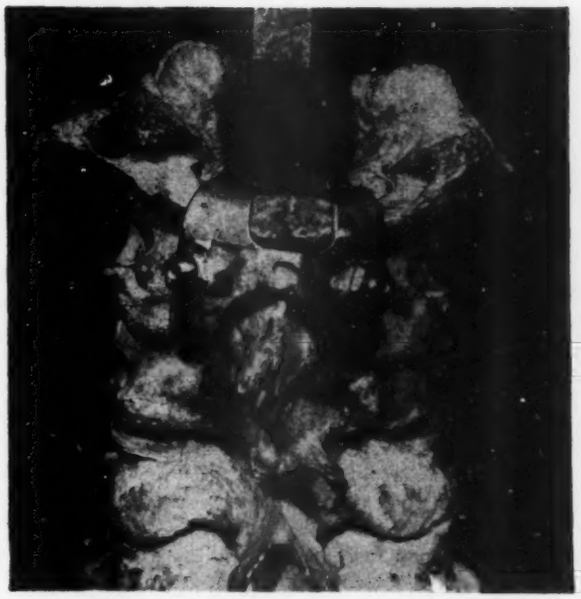


FIG. 8. Rough model of the "H" shaped clamp suggested by the authors to hold the posterior arches of the first and second cervical vertebrae together. The clamp is composed of two segments which are inserted independently over the arch of C_1 and under that of C_2. The two segments are then wired or screwed together.

Atlantoaxial dislocation in which there is a stable attachment of the odontoid process to the clivus or fusion thereof. This combination of circumstances, along with relaxation of the limiting ligaments of the odontoid, allow tipping of the base of the free odontoid process and potentially ventral indentation of the spinal cord. In these cases the atlas and head ride forward, narrowing the anteroposterior diameter of the spinal canal, so that the cord rides over the seemingly posteriorly displaced superior border of the body of the axis and the tipped odontoid and then, limited posteriorly by the ventrally slipped posterior arch of the atlas, tortuously turns upwards and dorsally into the foramen magnum. Here the life and function preserving operation consists in decompression of the posterior elements of the atlas and opening of the foramen magnum. If this is well tolerated, subsequently the axis should be fused to the occiput, to prevent progressive invagination of the ventral aspect of the cord by the tipped odontoid process.

Fracture of the odontoid process below its attachment to the axis. Fractures in this region heal surprisingly well. (Fig. 5.) Some of the reasons for this are obvious. First of all, the fracture is through true spongy bone of the axis whereas the odontoid per se is almost completely surrounded by a synovial membrane (Fig. 1), and cartilege so that fractures at or above the base tend not to heal well (in a manner similar to the navicular bone of the wrist). The presence of notochordal remnants in the base of the odontoid process also may interfere with healing in fractures of that region. Since the outlook for dealing in simple fractures of the odontoid below the base is excellent, external fixation is commonly successful in their management.

SUMMARY AND CONCLUSIONS

The phylogenetic and morphological complexity of the atlantoaxial unit are reflected in the many anomalies and combinations of anomalies and pathological change inherent in such a highly developed system. The fact that the pivotal motion of the head or neck depends upon the integrity of the odontoid process and that the center of gravity of the supported structures runs through it, along with its proximity to the anterior aspect of the cord, magnify the importance of lesions of the odontoid process in the development of pathological syndromes. The intricacy of structure and local relationships makes definitive radiographic analysis of prime importance in forming a basis for intelligent treat-

ment. In this study we have tried to outline a group of discrete entities with deductions as to their proper management based on clinical and x-ray analysis. The importance of laminography is emphasized along with the usefulness of special positions in obtaining good alignment prior to fixation. The gamut of operative procedures is described from simple decompression to preserve function to internal fixation of various types. A possibly more satisfactory means of stabilizing C1 on C2 is described. An attempt is made to bring out the relationship of anomalies, acute changes and sequential changes, in the final picture.

CONCLUSIONS

1. Anomalies of the odontoid process are commonly mistaken for fractures. This is especially true in children before ossification centers fuse. The multiplicity of centers and the complexity of the various joints lend themselves to such errors.

2. Atlantoaxial dislocation is common with these anomalies, with or without additional trauma.

3. The management of dislocation and fracture-dislocation of the first two cervical vertebrae is critically dependent upon the relationship of the odontoid process to the clivus, the atlas and the spinal cord.

4. Diagnosis is almost completely dependent upon the excellence of radiography. The use of laminography is stressed.

5. Errors in interpretation of the nature of the pathology may arise from the position adopted during the taking of x-rays.

6. The position of choice for the reduction of atlantoaxial dislocations is with the patient prone and adjustment of pressure against the chin.

7. A simple appliance for enhancing fixation of C1-C2 is demonstrated.

8. Atlantoaxial anomalies at some point in time may be innocuous. However, subsequent trauma or senescent changes may cause progressive and serious pathological change with the appearance of overt clinical syndrome of cord compression.

Acknowledgment: We wish to thank the members of the staff of the Columbia-University Medical Center who allowed us to utilize their cases.

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DISCUSSION OF PAPERS BY DRS. SULLIVAN, BRUWER AND HARRIS; AND SCHLESINGER AND TAVERAS

Carlo Scuderi (Chicago, Ill.): I wish to say that these were two very outstanding papers. I would like to know who coined the expression "whiplash injury of the neck," because not only I, but my four daughters would like to send this person a letter of thanks, because they have contributed a great deal to my annual income.

In the Chicago area, you know, there is always somebody bumping somebody else, and immediately there are two or three people complaining about pain in the neck. The lawyers in the Chicago area are very prone to instruct these people very well on how to conduct themselves when they are examined by a doctor, and how to conduct themselves when they get to court.

I am sure that Dr. Stack will bear me out that the number of whiplash injuries far outnumber the number of doctors who can examine them.

Now, we have men in the Chicago area who are much like the antique dealers in New Orleans who say, "How many worm holes do you want in the furniture?" They can make an antique to the year you want it. Unfortunately there are some doctors who will find as many fractures or dislocations in the neck as the lawyers want them to. I have the devil's own time in court trying to disprove what some of these men have testified to.

These two papers were outstanding for two reasons: First of all, they show that there is a possibility of having some changes in the neck that have nothing to do with an accident.

I was particularly interested in Dr. Sullivan's paper—to notice the differences in the amplitude of motion between the second and third cervical in normal children. Has there been any work done in adults? If there has been, I would love to talk to Dr. Sullivan and get additional information. If

there has not, it might be worth carrying on for the benefit of all of us.

The other aspect of Dr. Sullivan's paper which I noticed with great interest is the sloping anterior portion of the vertebral bodies. I am sure that carries over into adult life, and a lot of the patients we see in Chicago who are diagnosed as having mild compression fractures following whiplash injury have simply the carryover from childhood, because it never built up enough bone.

In regard to Dr. Schlesinger's paper, I thought he brought out one point that I am sure we are all aware of, but it ought to be re-emphasized. You cannot hold bone indefinitely by wire or prosthesis, or a plate. Eventually, you have got to have bone holding bone or living tissue holding living tissue. This situation of trying to hold the cervical vertebrae in place after trauma without first putting in fresh bone is doomed to failure.

I think these two papers are of outstanding interest, especially to those of us who have anything to do with medical-legal complications following accident.

Frederick Merwin Smith (New York, N. Y.): I would like to warn against confusion of diagnosis in certain fractures of the neck where other injuries may present a typical "red herring." A patient came to me several years ago, three months after an automobile accident in which he had been thrown forward (while asleep), striking his head on the dashboard. His original complaints were of pain in the head and in the neck. X-ray films of the skull were interpreted on admission and repeated a week later as showing no fracture. He was treated by bed rest and physiotherapy, the latter consisting of heat lamp, manipulations and exercises. A third x-ray examination was reported as showing no fracture.

At the end of three months his wife insisted on bringing him to this country. She also brought along all of his x-ray films. The lateral views of the skull fortunately included the first three cervical vertebrae, and when one's attention was focused on this region instead of the skull per se, it was quite obvious that there existed a fracture of the odontoid process with forward displacement of this fragment and C_1 of nearly ½ inch. No cord signs were present. The patient was then treated with a Gallie type fusion, using bone block and wire loop and kept in a Minerva jacket for four months. He now has no symptoms whatsoever.

I would also like to congratulate Dr. Sullivan on his contribution of x-rays in children showing the normal amount of mobility between C_2, C_3 and C_4. This should be very important in the future.

Alfred W. Farmer (Toronto, Can.): From a long experience at the Hospital for Sick Children in Toronto, I have seen many children admitted with so-called "crick in the neck." We have been aware, through our radiological department, of the changes which have been described in the x-rays.

When it was noted that Dr. Sullivan came from Rochester, I had to look at the program to see whether it was Rochester, New York, or Rochester, Minnesota, as some years ago we borrowed a film for residency teaching purposes from the group at Rochester, New York, demonstrating beautifully the changes which have been demonstrated here today. Have you any explanation for cause of the so-called crick in the neck when there is nothing showing in the x-rays except the normal variations which have been described? The usual treatment has been to place the patient in a halter for twenty-four hours. Most of them are well at that time and require no further treatment.

The demonstration today will spread the knowledge of the normal variations so that mistakes will not be made which involve immobilizing patients for long periods of time for something which is not of great significance.

With regard to the paper on the odontoid process, the speaker stated that this was a fairly easy operation. I have never performed it, but I have watched it being performed, as Dr. Gallie and Dr. Keith collaborated on this subject in a paper. It always appeared to me to be a rather difficult procedure because the approach and the maintenance of the position of the patient presented difficulties.

I would like to compliment both authors on their papers.

C. Roger Sullivan (closing): I happen to be from both Rochesters and I am familiar with the excellent cinefluorographic work carried out by the group at the University of Rochester. I believe Dr. Fielding of New York City has also done some of this work. I have not seen his motion pictures, but certainly cinefluorography should provide a marvelous tool for the study of hypermobility of the spine, as well as the so-called whiplash injury.

In answer to Dr. Scuderi's question, I am not aware of a similar study in the adult. I would certainly agree that in this "whiplash era" such a study might be very informative. Townsend and Rowe, however, indicated that with increasing age, hypermobility was lost.

In answer to Dr. Farmer's question regarding the youngster with "a crick in his neck," I would think this could be caused by any of the types of subluxation of the cervical spine not associated with fracture. Also, in the child with hypermobility of the cervical spine, such as those presented in our paper, injury may stretch ligaments and thus produce painful muscle spasm causing symptoms which may be misleading. Simple halter traction, heat and massage seem to relieve most of these patients.

Edward B. Schlesinger (closing): The only

thing I would like to leave with you is the idea of the numerous deceptive-appearing anomalies of the region. It is exciting to try to summarize them and analyze the complex problems one is faced with in differentiating them from traumatic lesions. It is obvious that it is impossible in a short time to describe them all and you will find there are many others.

One of the most fascinating anomalies is the hypoplastic odontoid, which is so small that it slides under the transverse ligament in the so-called somersault or Marjolin dislocation. The child's body flips over his head and the odontoid slips under with devastating results. These are statistically unimportant, but typical of the varying aspects of the pathology of the region.

Intravenous Fat As Supportive Therapy after Severe Injuries

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FOR many years it has been recognized that some method of administering fat intravenously would be a valuable adjunct for nutritional therapy in patients who were unable to take adequate calories by mouth. As early as 1920 Japanese scientists attempted to infuse a 3 per cent fat emulsion intravenously, but reactions such as chills and fever were so frequent that this work was abandoned.

In 1942 Stare initiated studies in his laboratory on the use of intravenous fat emulsions. Since that time he and other workers have used many different types of oils with varying results [1,2]. An emulsion based on one of Stare's recent formulas prepared as described in the paper by Meyer et al. [3] has been available on a clinical investigation basis since early in 1956. This emulsion (11,612 series)† has the following formula:

	Per 600 cc. Bottles	
	Grams	Calories
Cottonseed oil	90	810
Glucose	24	96
Soybean phosphatide	7.2	54
Polyoxyalkol	1.8	0
		960

The emulsion is prepared by high pressure homogenization and is sterilized in the final container by autoclaving at 15 pounds' pressure for twenty minutes. The great majority of the fat particles are under 1 micron in diameter. The foregoing formula appears to be stable for at least one year if kept at approximately 5°C.

The purpose of this report is to summarize the current status of this fat emulsion according to our clinical experiences and those of others. It will also present metabolic balance studies on malnourished and injured patients who received intravenous fat emulsion as supportive therapy.

STATUS OF THE PRESENT FAT EMULSION

The present preparation has been used by a number of investigators with very gratifying results. The emulsion seems to be well tolerated, and only a limited number of reactions have occurred. A summary of the clinical experiences at the University Hospital and the Jackson Veterans Administration Hospital is outlined in Table 1. A total of 302 units of intravenous

TABLE 1
SUMMARY OF CLINICAL EXPERIENCES WITH INTRAVENOUS FAT EMULSION

Condition of Patients	No.	Units Given	Reaction	Temperature above 100.6°F.	Maximum No. Units
Good	12	143	3	6	21
Fair	5	31	2	4	10
Poor	11	128	0	8	26
Totals	28	302	5	18	..
			7.6%		

† Lipomul-I.V.,® supplied by The Upjohn Company, Kalamazoo, Mich.

* Trainee, National Cancer Institute.

fat emulsion was given to twenty-eight patients. The incidence of reactions was 7.6 per cent, and most of these were benign fevers. The patients were divided into three categories: those in good condition, those in fair physical condition and those in poor condition. In the latter category, patients with severe burns, malnutrition and cachexia with infection or malignancy were included.

The reactions (Table 1) were divided into two groups: (1) chills, temporary fall in blood pressure or urticaria, and (2) temperature elevations above 100.6°F. Some investigators have noted pain in the back and chest with dyspnea. These usually are major reactions and come on early in the course of the infusion but disappear as soon as the infusion is stopped. None of these were noted in the aforementioned series. The less severe reactions, such as nausea, vomiting, abdominal discomfort, headache and dizziness, are usually very minor, and frequently, when the same patient is infused the following day, no untoward effects are noted. The most common response, which is termed a "reaction," is the rise in temperature to 100.6°F. or above. This is most often asymptomatic and does not occur until the end of the infusion or a few hours after its termination.

The maximum number of units given to any one patient is shown in Table 1. In the poor category one patient received 26 units of fat without any untoward effects. This was a severely malnourished colored female who had a very extensive burn. However, one patient with a malignancy of the esophagus and unable to take food by mouth received twenty-four units of intravenous fat emulsion over a period of twenty-five days and frank jaundice developed. When the emulsion was discontinued, the jaundice cleared. When he was given additional fat, jaundice developed after twelve infusions. Other investigators have reported that a few patients who have received large quantities of fat emulsion (twenty-one to thirty infusions over a fourteen- to twenty-eight-day period) have displayed a rather severe type of response, such as liver damage and interference with the coagulation mechanism, followed by petechiae and hemorrhage. In some patients there has been delayed severe fever, chills, thrombocytopenia and bleeding from the gastrointestinal tract. The exact cause and mechanism of these reactions in patients who have received large amounts of fat intravenously have not been explained. These reactions have occurred only in sporadic cases, as many patients have received large quantities of fat without any untoward effects. This phenomenon of interference with the coagulation mechanism and liver damage after multiple infusions of intravenous fat is the major problem requiring solution before complete acceptance is given for widespread clinical use.

FAT EMULSION AS SUPPORTIVE THERAPY

Several patients on the surgical wards were selected to be studied during the infusion of intravenous fat. Most of these patients needed supportive therapy. Many were persons who were injured and were unable to take food by mouth. Other patients had fistulas and malignancy of the esophagus prohibiting oral alimentation.

The care of these patients was under the supervision of the staff of the Metabolic Study Group. All intake, except water and black coffee, was by the intravenous route. Twenty-four-hour collections of urine, stools and vomitus were made, and the nitrogen content was determined by the boric acid modification of the Kjeldahl procedure [4]. The fluids used for intravenous alimentation were protein hydrolysate* and a fat emulsion. These were analyzed for nitrogen content by the same method. The protein hydrolysate solution contained 6.79 gm. of nitrogen per L., and the intravenous fat emulsion 0.39 gm. per 600 ml.

A typical effect of the fat emulsion was demonstrated in a sixty-four year old white man with carcinoma of the esophagus. He was unable to take food by mouth and was put on intravenous feedings. The period of investigation was divided into three-day study periods. In one period the patient received protein hydrolysate, alcohol and glucose solution, supplemented by infusions of intravenous fat. On the alternate study periods the protein hydrolysate solution only was infused. The total nitrogen balance for the period and the average daily nitrogen balances are shown in Table 11 (1 gm. of nitrogen represents 6.25 gm. of pro-

* Protein hydrolysate solutions were supplied by Mead Johnson & Company, Evansville, Ind. One solution was amigen® 800, containing 5 per cent amigen, 12.5 per cent levugen,® and 2.4 per cent alcohol. This contained 37.5 gm. of protein and 800 calories per L. The other solution used in these studies was amigen 5 per cent with glucose 5 per cent, containing 37.5 gm. of protein and 345 calories per L.

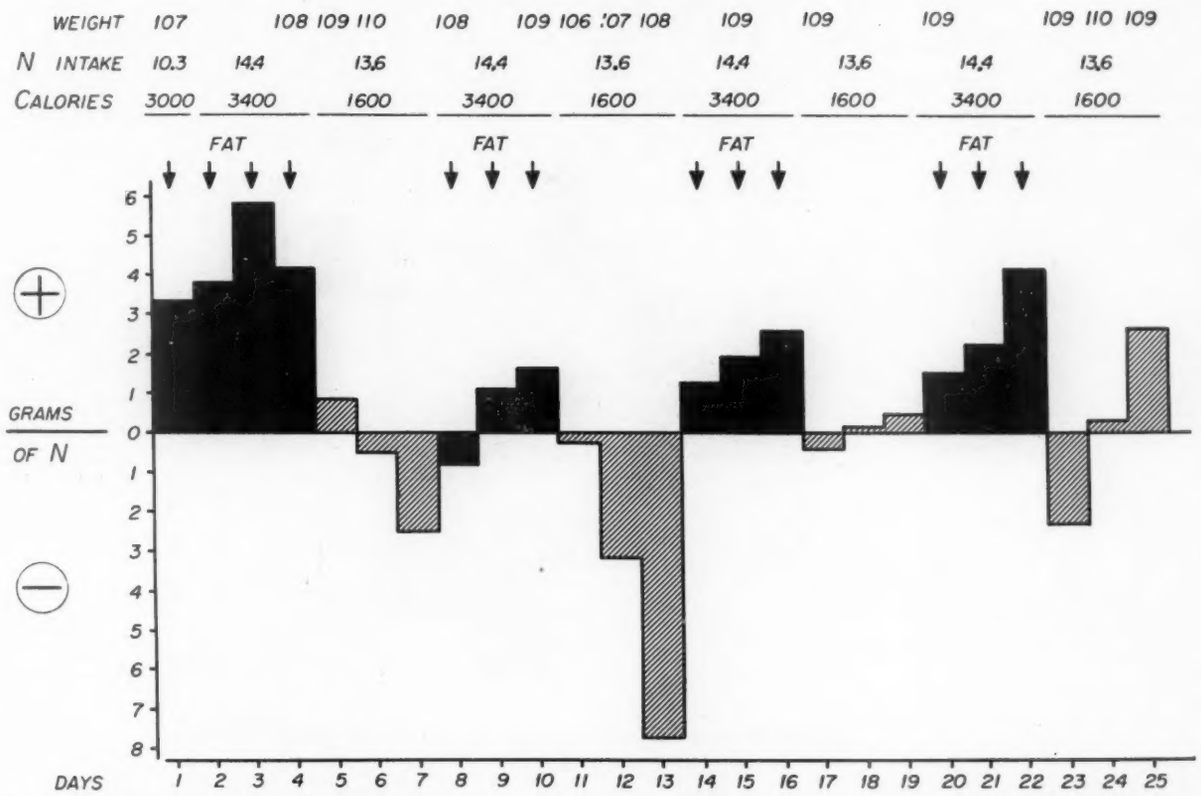

FIG. 1. Nitrogen balance data on a sixty-four year old white man weighing 50 kg., who had carcinoma of the esophagus. The area above the zero line denotes positive balance, and the area below the zero line negative balance. The black areas show the time during which the patient was receiving intravenous fat emulsion in addition to a protein hydrolysate-glucose-alcohol solution. The cross hatched areas denote the period in which the patient received only the protein hydrolysate glucose alcohol mixture. The patient maintained his weight during the twenty-five days of study. It is obvious that while the patient was receiving 14.4 gm. of nitrogen and 3,400 calories he stayed in very positive balance; but when the number of calories was decreased, he tended toward a negative balance, and as soon as additional calories were supplied by intravenous fat he went into positive balance. This demonstrates the effect of additional calories supplied by the intravenous fat in supporting the storage of nitrogen.

tein). When the patient was on protein hydrolysate only, as in periods 2, 4, 6 and 8, he received 600 calories and 13.6 gm. of nitrogen daily. During the other periods he received additional calories from the infusion of two units (600 ml. per unit) of intravenous fat emulsion, for a total daily intake of 3,412 calories. There was a very small amount of nitrogen in the fat emulsion, making the total daily intake 14.4 gm. It can be easily seen from the period balances and from the average daily nitrogen balances that the additional calories, supplied by the intravenous fat emulsion, kept the patient in a very positive balance, whereas the balance was on the negative side or just slightly positive when he received only the protein hydrolysate solution.

The daily balances and weight changes are better shown in Figure 1. During the twenty-four-day period he maintained his weight. In fact he gained 2 pounds; however, he was a

TABLE II
DATA ON SIXTY-FOUR YEAR OLD WHITE MAN WITH CARCINOMA OF ESOPHAGUS

Period (3 days)	Infusion	Daily Calories	Daily N Intake	Period Balance	Average Daily N Balance
1	Protein* and fat†	3,412	14.4	+13.73	+4.60
2	Protein hydrolysate*	1,600	13.6	− 2.13	−0.71
3	Protein and fat	3,412	14.4	+ 1.88	+0.63
4	Protein hydrolysate	1,600	13.6	−10.96	−3.65
5	Protein and fat	3,412	14.4	+ 5.66	+1.88
6	Protein hydrolysate	1,600	13.6	+ 0.08	+0.02
7	Protein and fat	3,412	14.4	+ 7.80	+2.60
8	Protein hydrolysate	1,600	13.6	+ 0.60	+0.20

* The protein was supplied as amigen 800 (amigen 5%, levugen 12.5%, alcohol 2.4%); 1 L. of this solution provides 37.5 gm. protein (by actual analysis 6.79 gm. of nitrogen) and 800 calories.
† The fat was given as lipomul-I.V. containing 0.39 gm. of nitrogen and providing 906 calories per unit of 600 ml.

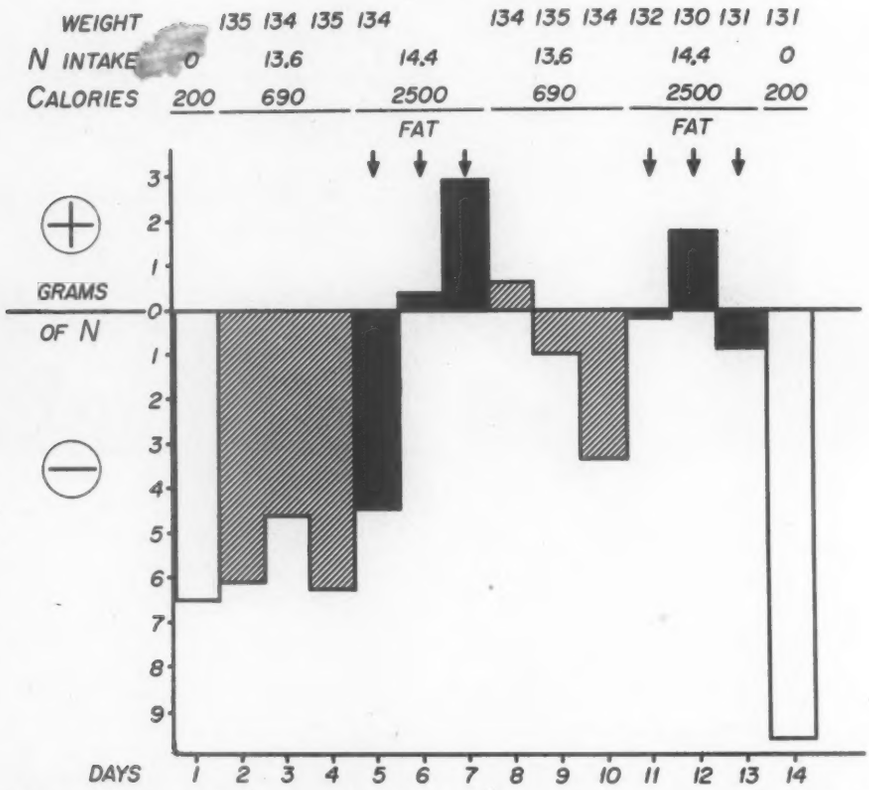

FIG. 2. Nitrogen balance data on a forty-two year old white man, who had a large stasis ulcer of the leg. The area above the zero line denotes positive balance, and the areas below the zero line negative balance. During the first and fourteenth days of the study, when the patient received only glucose and water, there was a marked negative nitrogen balance. During the three-day periods, when the patient received 5 per cent protein hydrolysate and 5 per cent glucose solution, shown by cross hatched areas, he was in negative nitrogen balance. However, when additional calories were supplied by intravenous fat, he tended toward positive balance, or at least a less negative balance. This demonstrates the value of additional calories supplied as intravenous fat emulsion to maintain an individual in positive balance.

small individual at bed rest and therefore received adequate amounts of protein and calories for basal requirements. The graph shows that as the patient received protein hydrolysate with additional fat emulsion, the balance became positive. During the first period of protein hydrolysate solution only the balance became less positive, then negative. This negativity increased until the next period of supplemental fat emulsion began, when the balance returned to the positive side. This patient's study, like several others, showed the protein-sparing effect of additional calories supplied by the intravenous fat emulsion.

TABLE III

DATA ON FORTY-TWO YEAR OLD WHITE MAN WEIGHING 62 KG., WITH POSTPHLEBITIC ULCER OF LEG

Period (3 days)	Infusion	Daily Calories	Daily N Intake	Period Balance	Average Daily N Balance
1	Protein hydrolysate*	690	13.6	−17.06	−5.68
2	Protein and fat	2,502	14.4	− 1.24	−0.41
3	Protein hydrolysate	690	13.6	− 4.20	−1.40
4	Protein and fat	2,502	14.4	+ 0.67	+0.22

* Amigen 5%, 1 L. provides approximately 37.5 gm. of protein (by actual analysis 6.79 gm. of nitrogen) and 345 calories.

The next patient, a forty-two year old, white man weighing 62 kg., had a very extensive postphlebitic ulcer of the left lower leg. He was put in bed to keep his leg elevated in preparation for surgical excision and grafting. During this time studies were carried out to evaluate the effect of fat emulsion on nitrogen balance when limited calories were used. The average daily nitrogen balance and period balances are shown in Table III. A 5 per cent protein hydrolysate, 5 per cent glucose solution, containing 345 calories per L., was used during periods 1 and 3, and the same solution with the addition of two units

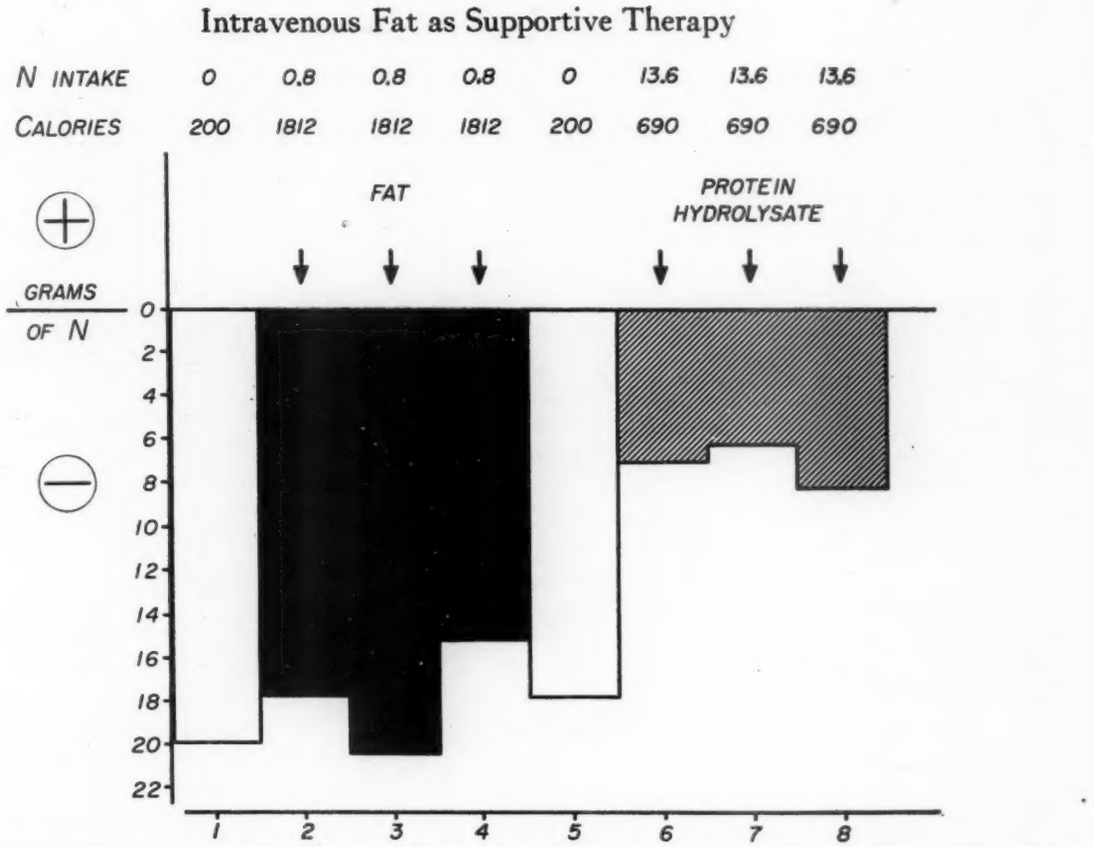

FIG. 3. Nitrogen balance data on a nineteen year old Negro man, who had a rather severe injury with fracture of the maxilla, fracture of the femur and multiple lacerations of the leg. He was unable to take food by mouth. Throughout the eight-day period of study he had a limited number of calories and was in negative balance during the entire period. During the first and fifth days he received only 200 calories in the form of intravenous glucose and was in marked negative nitrogen balance. When he was given intravenous fat, two units daily, his negative nitrogen balance, as shown by the solid black area, was somewhat less. However, the appreciable change in decreasing the negativity of the balance came when he received a protein hydrolysate solution on the sixth, seventh and eighth days (cross hatched area). At no time during the study did he have an adequate number of calories along with an adequate amount of nitrogen. During the last three days of the study there appeared to be an adequate amount of nitrogen, provided by the protein hydrolysate, but the caloric content was too low and the patient apparently utilized the calories supplied by the protein for energy requirements. This demonstrates that intravenous fat will provide calories, but both calories and nitrogen are required for positive balance.

of intravenous fat emulsion during periods 2 and 4. During the first period there was a total negative balance of 17 gm. of nitrogen, which decreased in negativity to 1.24 gm. after the addition of supplemental calories by means of the fat emulsion. During the third period, when protein hydrolysate only was given, the negativity increased to 4 gm., and as the fat emulsion was added in period 4 the balance became slightly positive. The daily balances are shown in Figure 2. The positivity of the balance was not as marked in this patient as in the previous one who had a malignancy of the esophagus, because the total number of calories given was less. This patient's weight dropped from 135 to 131 pounds, which probably reflects the inadequacy of caloric intake for a man weighing 62 kg. However, there is evidence that during the time the patient was on intravenous fat emulsion the nitrogen balance tended more toward equilibrium or positivity, again showing the protein-sparing effect of additional calories through the use of intravenous fat emulsion.

In Figure 3 is shown the graphic representation of daily balance in a nineteen year old Negro man who received a severe fracture of the maxilla, fracture of the femur and multiple lacerations of the right lower extremity. This individual with a severe injury was unable to take food by mouth for several days and therefore was put on the study program. It was decided to evaluate for a short time the balance during the administration of intravenous fat only, with no nitrogen intake, and then during

a period of nitrogen intake in the form of 5 per cent protein hydrolysate with limited calories. During the patient's first and fifth days of study he received only dextrose and water, 200 calories, without nitrogen. His daily nitrogen loss during this period was about 19 gm.

TABLE IV

DATA ON FORTY-TWO YEAR OLD NEGRO MAN WEIGHING 73 KG., WITH A 20 PER CENT BURN OF 2ND AND 3RD DEGREE

(AVERAGE DAILY NITROGEN EXCRETION, 13.45 GM.)

Infusion	No. of Days	Daily Calories	Daily N Intake	Average Daily N Balance
*Protein hydrolysate-alcohol-glucose	6	1,600	13.6	−0.18
Protein hydrolysate-alcohol-glucose and fat emulsion	4	3,400	14.4	+1.80

* Amigen 800 solution.

During the period on intravenous fat, when 1,800 calories were given daily, the negativity of the nitrogen balance decreased. However, the greatest decrease in negativity occurred when nitrogen was given in the form of protein hydrolysate. This case demonstrates the advantage of administration of protein and that calories in the form of intravenous fat emulsion will decrease the negativity of the nitrogen balance. Obviously the important aspect in therapy is that both adequate amounts of protein and calories are given if positive nitrogen balance is to be achieved.

Three additional patients with various forms of injury demonstrate different aspects of the effect of protein hydrolysate and fat emulsion on nitrogen balance. A forty-two year old Negro man weighing 73 kg., with second and third degree burns covering 20 per cent of his body surface, was put on study on the fourth postburn day. His average daily nitrogen excretion by the urinary route was 13.45 gm. per day. A protein hydrolysate-alcohol-glucose solution and the same solution with the addition of two units of intravenous fat emulsion were given during alternate study periods. The data are shown in Table IV. This patient's daily nitrogen intake on both types of alimentation was 13.6 to 14.4 gm. During the days in which protein hydrolysate-alcohol-glucose solution was infused there was an average daily nitrogen balance of minus 0.18 gm. However, when additional calories were supplied by the fat emulsion, he maintained a mildly positive balance of 1.8 gm. of nitrogen a day. It appears that the addition of calories in the form of fat emulsion caused him to remain in positive balance in spite of rather large losses of protein following the burn injury.

TABLE V

DATA ON THIRTY-ONE YEAR OLD NEGRO WOMAN WEIGHING 51 KG., WITH GUNSHOT WOUND OF FACE

Infusion	Daily Calories	Daily N Intake	Average Daily N Balance
Glucose	200	0	−5.55
Fat emulsion	2,416	0.9	−3.56

In another patient, a thirty-one year old Negro woman with a gunshot wound of the face, who was unable to take food by mouth, evaluation was carried out by giving glucose solution with 200 calories per day during one period and fat emulsion, two units daily, during the other period. There was essentially no protein given during this study. It can be seen in Table V that the daily balance in this individual without nitrogen intake was minus 5.5 gm. However, when the fat emulsion was given, the negativity of nitrogen balance was decreased to minus 3.5 gm. per day. Although neither regimen was sufficient for the desired therapeutic effect, this study shows that the addition of the fat emulsion decreased the negativity of the nitrogen balance. It must be pointed out, however, that this patient was a woman and therefore probably the nitrogen losses were less than in a larger male patient.

In another patient, a forty-two year old Negro man weighing 70 kg., who had a fracture of the mandible and was unable to take food by mouth, a similar study showed that the additional calories provided by the fat emulsion did not appreciably change the negativity of nitrogen balance. (Table VI.) It appears that this 70 kg. man required considerable calories, and the 2,000 calories provided by the fat emulsion did not appreciably change the negativity of the nitrogen balance beyond that seen when glucose only was given. With the exception of this one patient, however, all pa-

tients showed the protein-sparing effect of the intravenous fat emulsion under varying circumstances of study.

In these six representative metabolic balance studies it can be seen that intravenous fat emulsion provides additional calories and has a protein-sparing effect. It is obvious that the aim in the treatment of patients should be to provide an adequate nitrogen intake and, in addition, adequate calories so that the protein is spared from being utilized as calories to provide energy requirements. A protein hydrolysate solution may provide protein and minimal calories, and the addition of one or two units of intravenous fat emulsion will provide the necessary additional calories. Calories may be provided by the fat emulsion, but this alone is inadequate therapy. However, the emulsion will assist in decreasing the amount of negativity of the nitrogen balance. Therapeutically, the greatest value from the fat emulsion lies in supplying additional calories when an adequate amount of nitrogen is given. Although 2 L. of protein hydrolysate-alcohol-glucose solution, supplying 800 calories and 37.5 gm. of protein per L., are usually not adequate to maintain positive balance in most injured people, the additional calories supplied by one or two units of fat emulsion provide the necessary calories to maintain near nitrogen equilibrium if the nitrogen losses are not too great.

TABLE VI

DATA ON FORTY-TWO YEAR OLD NEGRO MAN WEIGHING 70 KG., WITH FRACTURE OF MANDIBLE

Infusion	Daily Calories	Daily N Intake	Average Daily N Balance
Glucose	200	0	−8.68
Fat emulsion	2,174	0.9	−8.49

COMMENTS

It is well recognized that additional calories are very beneficial in various types of surgical patients and in individuals who are injured. There is now abundant evidence from many investigators that fat emulsion given intravenously is a good method of administering calories and that it does have a protein-sparing effect [5]. Shingleton, Anylan, Salem, and Sanders [6] found that intravenous fat emulsion was effective in decreasing negative nitrogen balance during prolonged inadequate caloric intake. Levey, Kreiger, Benson, Davis and Abbott [7] studied the effect of administering fat emulsion intravenously and protein hydrolysate solutions to patients in the immediate postoperative period. They found that the fat emulsions decreased the nitrogen deficit in postoperative patients.

In addition to patients who require their total alimentation intravenously, some individuals can take a limited amount of food by mouth but need supplemental calories. To give this in the form of a fat emulsion orally causes nausea and is not well tolerated. Intravenous fat emulsion to supplement limited oral intake is sometimes very beneficial.

It might seem that fat given intravenously would lead to fat embolism. During the past five or six years hundreds of patients have received intravenous fat emulsions, and there has been no evidence of fat embolism. Conceivably, the infusion of the fat emulsion could cause an appreciable rise in the serum cholesterol level and therefore be detrimental. Waddell and Lever [8] have shown that the serum cholesterol level does not rise after intravenous fat emulsion, but actually falls. In some hypercholesteremic diseases these investigators found that it was possible to reduce cholesterol levels from 500 to 600 mg. to as low as 250 mg. in six or seven days of daily fat infusion.

The status of the present fat emulsion is that it is very beneficial and acceptable in moderate doses. The reactions are not serious and occur in only a small percentage of infusions. Actually, most of the patients who experience reactions can be reinfused with the fat emulsion on the following day without untoward effects. However, the problem concerning complete acceptance of intravenous fat has to do with how much fat can be infused before there is damage to the liver and untoward changes in the coagulation mechanism. At the present time sporadic patients have been reported to have had major difficulties after infusions of twenty or more units of fat emulsion [9,10]. On the other hand, many patients have received thirty or forty infusions without any untoward effects. Intravenous fat emulsion has been established as a useful adjunct in the management of patients who need calories by the parenteral route. The present emulsion

seems to be safe and effective in limited amounts. Further studies presently being carried out in various centers throughout the country should clarify the problems of interference with liver function and the coagulation mechanism in patients who have received large quantities of the fat emulsion.

SUMMARY

A total of 302 units of a commercially prepared fat emulsion was given to twenty-eight patients. During five of the infusions, reactions such as nausea, chills and urticaria occurred. These were very minor and the patients showed no untoward effects when reinfused with fat emulsion on the following day. After eighteen infusions in various patients a benign rise in temperature to above 100.6°F. was noted. Only one patient showed a serious response. This consisted of jaundice after twenty-four infusions.

At the present time it appears that moderate quantities of fat emulsion are safe for clinical use, but large quantities may evoke a severe response. Interference with liver function and the coagulation mechanism after intravenous fat emulsion infusions over a prolonged period is the primary problem requiring further study.

Metabolic balance studies were carried out on several patients. Data on six typical patients show the protein-sparing effect of intravenous fat emulsion. This preparation appears to be a useful adjunct in injured patients and other patients who are unable to take adequate calories by mouth.

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Observations in Vascular Dynamics during Hemorrhagic Shock and Its Therapy

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SHOCK is probably the most common of the serious problems among surgical patients. The fact that a delay in treatment will result in a resistance to recovery is well known. Use of whole blood in the treatment of shock is the usual procedure, especially if shock is due to blood loss. In recent years, however, vasoconstrictor drugs have become a common medium in the treatment of hemorrhagic and non-hemorrhagic shock. These drugs have their effect not on the replacement of circulatory volume, but rather by decreasing the total circulatory capacity through constriction of the vessels. The increase in tension caused by the constriction is observed in the larger arteries as an increase in the blood pressure. A sense of security exists, which may be quite transitory. Clinically, once vasoconstrictor drugs have been used, response to the use of blood is increasingly poor, and as time progresses, greater amounts of the drug are necessary to maintain blood pressures.

The common use [1–3] of vasoconstrictor drugs in the treatment of shock and our observance of resistance to treatment after its use have prompted us to investigate the effects upon the blood vessels.

A study and record have been made of some of the compensatory changes which take place in the vascular system during controlled shock and its treatment. In this study we compare the responses which take place with blood replacement to those which occur when a vasoconstrictor drug is used. We have chosen to use the vessels in the wall of the small bowel of the rabbit because they are the most similar to human vessels of the laboratory animals [4] and because the portal system is considered to hold one-third of the circulating blood volume [5] in the body. We reason thereby that the portal system should represent a reasonable percentage of vascular response in the body during shock.

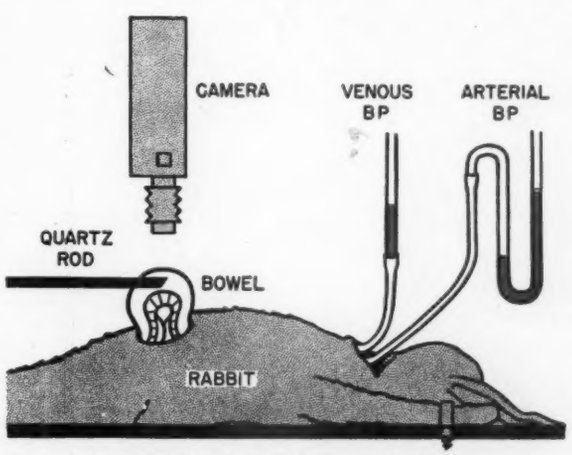
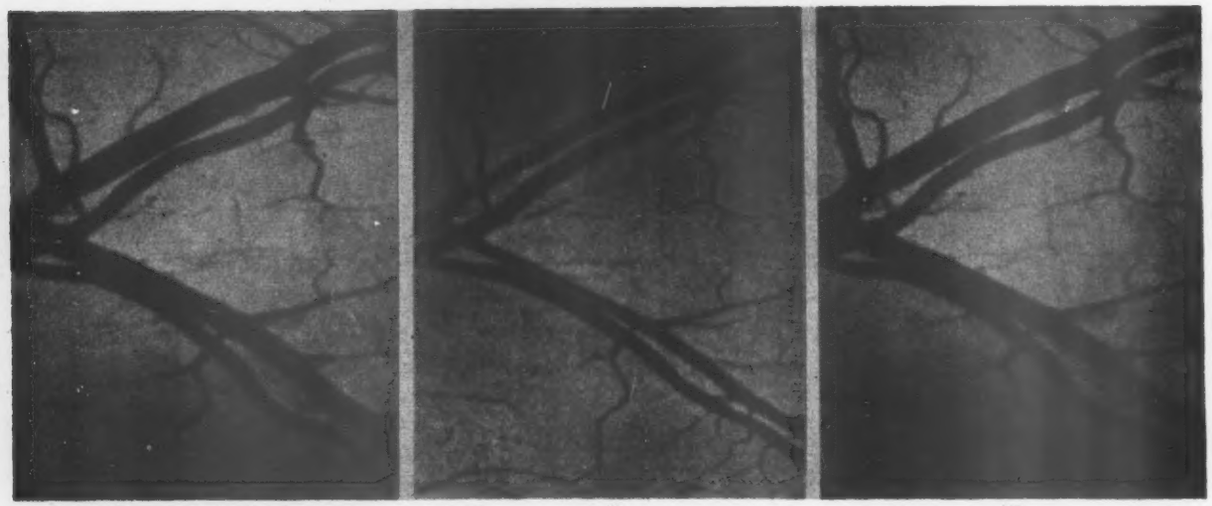


FIG. 1. Transillumination apparatus.

METHOD OF STUDY

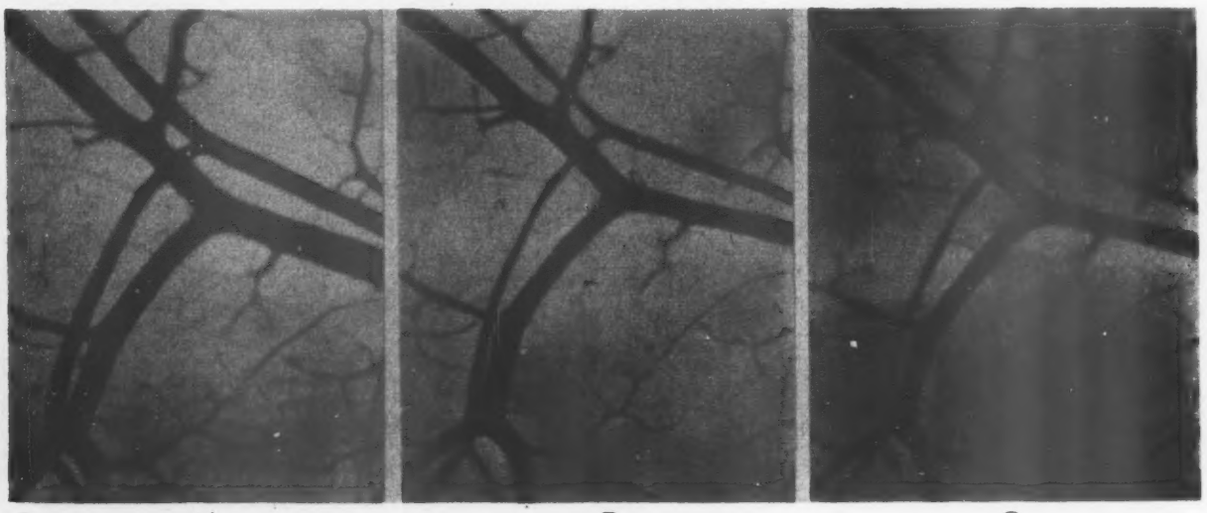
In order that good observations and a photographic record could be made under controlled conditions, a special arrangement of the animal and apparatus was necessary. (Fig. 1.)

A 5 pound rabbit is anesthetized with intravenous nembutal.® It is then heparinized so that blood can be removed and replaced at will. A tracheotomy is performed to eliminate the factor of anoxia on the vascular system. Cannulas are placed in the left carotid artery and right superior vena cava by way of the jugular vein. These, in turn, are attached to manometers so that a constant knowledge of



2A 2B 2C

FIG. 2. A, normal, blood pressure 100 mm. Hg; B, hemorrhagic shock, blood pressure 75 mm. Hg; C, blood replacement, blood pressure 100 mm. Hg.



3A 3B 3C

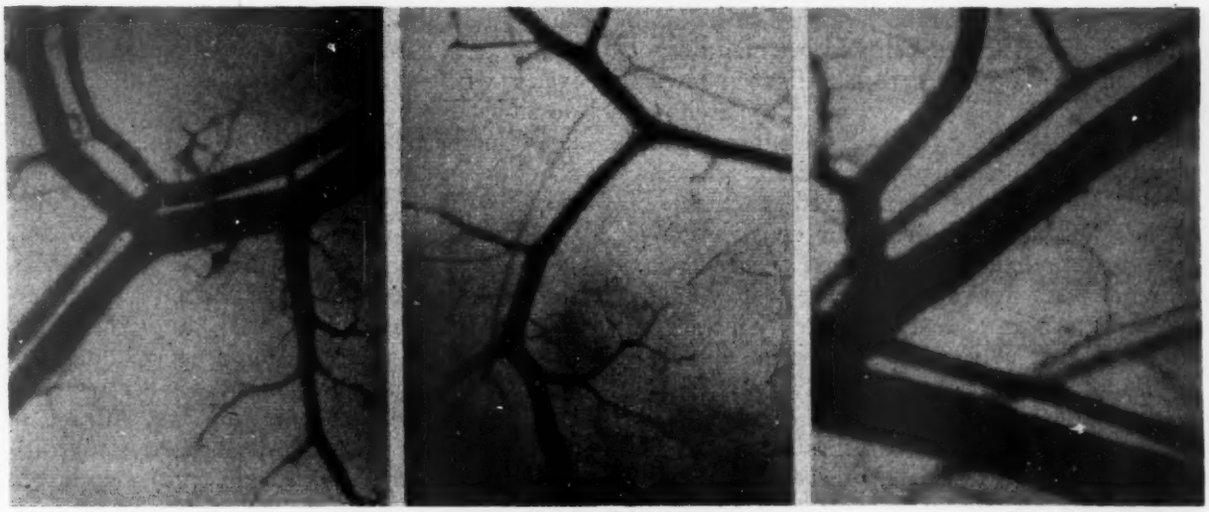
FIG. 3. A, normal, blood pressure 100 mm. Hg; B, hemorrhagic shock, blood pressure 75 mm. Hg; C, vasopressor effect, blood pressure 100 mm. Hg.

the blood pressures in these systems is available. A mercury manometer is used for the arterial blood pressure and a saline manometer measures the venous blood pressure. The loop of small bowel of the rabbit is then lifted through an incision in the abdominal wall. The bowel is transilluminated by a quartz rod using a 1,000 watt projector bulb as a light source. It is maintained in a moist state by irrigation with normal saline solution which has passed through a constant temperature water bath.

Observations are made by the stereo dissecting microscope and vascular changes are recorded by 16 mm. cinephotomicrography. Selected figures have been reproduced from the movie to illustrate the changes which take place. (Figs. 2 to 4.)

PROCEDURE

As would occur in the human being, an early state of hemorrhagic shock may be produced by removal of 30 per cent of the circulating blood volume from the rabbit. This is best accomplished by using a three-way stopcock interposed between the cannulas and manometer. The blood pressure drops from a normal mean pressure of 100 mm. Hg



4A 4B 4C

FIG. 4. A, normal, blood pressure 100 mm. Hg; B, hemorrhagic shock, blood pressure 30 mm. Hg; C, shock without blood loss, blood pressure 30 mm. Hg.

to 75 mm. Hg. Observations are made of the changes occurring in the capillary and precapillary system of vessels. The hemorrhagic shock is then treated by replacement of the previously removed blood. Blood pressure and microscopic vascular dynamics return to normal. (Fig. 2.) In a second rabbit hemorrhagic shock is produced in the same manner with the same resultant blood pressure of 75 mm. Hg. It is treated by a slow instillation of a diluted solution of vasoconstrictor drug sufficient to bring the blood pressure up to 100 mm. Hg. (Fig. 3.) Once the administration of the drug is stopped the blood pressure drops at once to 75 mm. Hg. It does not stop there, however, but continues to drop to 50 and 30 mm. Hg. Administration of previously removed blood does not return the blood pressure to normal but only to 80 mm. Hg. It then drops again to 20 and 10 mm. Hg. and usually on down to an unobtainable blood pressure with death of the animal. For the sake of comparison, observations have been made of the changes which take place in shock due to vasodilatation. (Fig. 4C.)

OBSERVATIONS

Normal capillary and precapillary blood flow is a dynamic situation consisting of an extremely rapid flow of cells through these vessels [6]. The small arterioles pulsate widely with a flow which speeds and slows through each cycle of pulsation. The individual cell is difficult to see because of the vessel diameter and their rapidity of flow. With intestinal peristalsis there is a coiling and uncoiling of these vessels. Associated with peristalsis is a tendency in vessels of this and smaller size for the blood to change its direction of flow as if a road block had been set up and an alternate route must be selected. As smaller vessels of capillary size are approached, the cells form double and, finally, single file to pass on across to the venous capillaries. As peristalsis occurs, one can observe the rectangular pattern of capillaries in the circular and longitudinal muscle layers pass back and forth across each other. The pulsatory progression of cells ceases as they pass over into the venous capillaries and venules. Small veins maintain a normal 3:2 ratio with the small arteries. (Fig. 2A.) The slower rate of flow on the venous side allows one to observe more rapid flow of cells in the center of vessels and a pattern of cell flow which may be called lamination. Cells which come into a larger vein by way of a tributary on one side tend to flow down that side of the larger vein without mixing. There is little tendency for the cells to clump while blood pressures are normal.

Hemorrhagic shock is associated with immediate loss of amplitude in the pulsations of the arteries. There is early constriction of both the veins and arteries as in Figure 2B. There is somewhat greater narrowing of the artery as might be expected because of the

greater quantity of smooth muscle in its wall. In capillaries of single cell width which do not show on the photomicrograph, cells stop flowing and many capillaries empty completely of blood cells making them no longer visible through the stereo dissecting microscope. One is impressed by a generalized paleness of tissue. The degree of vascular constriction is directly proportional to the loss of circulating volume. With slowing of the rate of flow in the vessels there is a tendency for the cells to stick together or clump as has been observed by Knisely [7]. This is observed first in the veins because of the slower rate of flow in them. A tendency for cells to stick along the sides of the vessel exists, whereas there is a greater rate of flow in the center. Periodically the direction of flow may change in veins, especially when the pressure is low. In shock, cyanosis tends to develop on the venous side because of the greater degree of oxygen extraction when the cell flow is slow.

Blood replacement in hemorrhagic shock, providing it is early, results in a complete return of capillary dynamics to their normal state. First, pulsation returns in the arterioles; then cells begin to flow again in the capillaries. There is a dilution of the cyanosis, then a clearing of it. The arteries and veins return to their former size, the previous rate of flow is resumed and cell clumps break up. The tendency to clump disappears. The carotid blood pressure returns from 75 mm. Hg to the normal 100 mm. Hg, and as in Figure 2C, the vessels return to their normal size. Figures are reproduced from a 16 mm. film taken by cinephotomicrography during the treatment of hemorrhagic shock by blood replacement. Figure 2A represents the normal arteriovenous ratio with a blood pressure of 100 mm. Hg, (B) hemorrhagic shock, (C) after blood replacement.

Vasoconstrictor drugs likewise are used in hemorrhagic shock to return the blood pressure from 75 mm. Hg to 100 mm. Hg in a second series of animals. Sufficient drug is given slowly in a very dilute solution to bring the blood pressure in the carotid artery up to a normal 100 mm. Hg as recorded by the attached manometer. In this instance the arteries resume their normal pulsations, but instead of dilating as with blood replacement the arteries further constrict. Often they constrict in a segmental pattern, then partially dilate at that point and constrict at another point. (Fig. 3C.) Gradually they completely constrict with very little effective blood flow possible. Flow in the capillaries at first has been increased but shortly ceases. The constriction in the small veins is minimal. With the slow flow of blood, clumping develops. Cyanosis is evident on the venous side and severe blanching exists. Figure 3 represents the normal picture (A), the normal response to 30 per cent blood loss (B), and the early response to vasoconstrictor drug (C), demonstrating segmental constrictions with a return of blood pressure to 100 mm. Hg. After discontinuing the use of vasoconstrictor drug, blood pressures drop to the previous levels but do not stop there. They continue to drop to 20 or 30 mm. Hg. At this point the previously withdrawn 30 per cent of blood volume is returned, bringing about a rise of blood pressure to 80 mm. Hg. This is usually temporary, however, with a return to shock and frequently death of the animal. Dilatation of the vessels may occur, but vessel tone no longer exists in a sufficient degree to maintain blood pressures. It is as if the blood vessels are tired and do not respond in a normal way to the normal vasoconstrictor factors of the body. A state of irreversible shock exists.

In order to illustrate the extremes that may be observed by this method of study, two extremes in response are illustrated in Figure 4. The normal vascular pattern in Figure 4A is compared with (B) where the blood pressure is 30 mm. Hg. Here a state of rebound shock exists following the use of vasoconstrictor drugs. The arteries are severely constricted without comparable venous constriction. In (C) a blood pressure of 30 mm. Hg without blood loss also exists but is due to the administration of arfonad® with the resultant dilatation of the vein and some narrowing of the arteries as appears to occur in all types of shock. The magnification in (B and C) is the same as in (A) so that the arterial and venous sizes in two types of shock may be compared with the normal.

SUMMARY

In order to better understand the changes which occur in vessels during hemorrhagic shock and its treatment, we have studied the vascular changes with the dissection microscope and made a record by cinephotomicrography.

Both blood replacement and use of vasoconstrictor drugs will give rapid return to normal blood pressures. Only blood replacement, however, will return the microscopic picture to normal. The vasoconstriction, resultant tissue anoxia, failure of pressures to persist and increased resistance to further treatment would contraindicate the use of vasoconstrictor drugs in hemorrhagic shock. Our clinical experience is in agreement with the laboratory findings.

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The Use and Abuse of Tetanus Antitoxin in Acute Injuries

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THE striking reduction of Clostridium tetani infections following trauma sustained by military personnel during World War II and the Korean conflict demonstrates the effectiveness of the active immunization program against tetanus practiced by the Armed Forces. This immunity is satisfactorily upheld by the use of booster doses of tetanus toxoid at appropriate intervals. An effort to actively immunize the civilian population by routine administration of tetanus toxoid during infancy is primarily thwarted by failure to maintain the immunity with booster doses during the ensuing years.

There is a trend in civilian practice toward giving tetanus antitoxin as part of the initial therapy for traumatic lacerations, regardless of etiology, location, extent of tissue damage or method of local care. Compounding this abuse is either the complete neglect of appropriate sensitivity tests or the failure to allow a suitable interval to elapse between testing sensitivity and administering the antitoxin.

The purpose of this report is to assay current concepts of tetanus prophylaxis accompanying the definitive care of trauma.

BACTERIOLOGY

The incubation period is usually described as the length of time from reception of the wound until the first symptom of clinical tetanus, usually trismus, appears. If infection has occurred sometime after the wound has been received the incubation period may actually be shorter than it appears and hence misleading.

It has been demonstrated that the shorter the incubation period, the poorer the prognosis. This may either be the result of virulence variability of tetanus bacilli or result from alterations in host resistance to Cl. tetani.

The organism gives rise to two separate exotoxins, both of which possess antigenic properties. The more important of these toxins, a neurotoxin (tetanospasmin), is responsible for the clinical picture of tetanus. The less important toxin, often referred to as tetanolysin, is a hemotoxin.

The neurotoxin of tetanus is one of the most powerful toxic agents known to man. It has a definite affinity for the brain and spinal cord of susceptible hosts. Because the union of toxin and cerebral tissue can be broken by disintegration of the tissue cells, leaving the toxin undamaged, it is believed that the reaction is one of adsorption.

While controversy still exists as to the exact pathogenesis of tetanus [2], present concepts implicate a dual mechanism of action, each independent of the other. The central effect, caused by direct action of the toxin on the motor nerve cells of the medulla, pons and spinal cord, is manifested by motor convulsions. The peripheral effect, a result of the toxin bathing the motor end organs, produces spasm of the voluntary muscles.

WOUND

In approaching the decision for passive immunization, one should consider the individual wound as a potential breeding ground for clostridial spores. Of prime importance is the recognition that an anaerobic medium is required for growth and multiplication of tetanus bacilli. Growth is accelerated where tissue necrosis from inadequate blood supply and impaired oxygenation exists. Interference with cellular respiration and metabolism ensues, providing an anaerobic culture medium.

Review of the literature reveals that the

majority of tetanus infections have followed penetrating or puncture type wounds, particularly of the extremities. These injuries have often been incurred in rural areas where contamination occurs when the initial penetration carries tetanus spores present in the soil. The natural anatomy of the extremities, particularly the fascial compartments of the hands and feet, provides an excellent sealing effect following introduction of the missile. So very often superficial injury appears to be minimal and the wound is categorized as a "slight" one. Often these minor injuries become infected and seal with a scab forming a cavity where anaerobes grow and multiply. Injuries such as these account for more than 80 per cent of the reported cases. While it is not the purpose of this report to discuss the local care of the wound, the primary emphasis is on attention to the basic surgical principles of wound care. Broadly, the aim is to convert an anaerobic medium into an aerobic one with minimal disturbance to normal tissue, thorough débridement of necrotic tissue, and adequate drainage.

TOXOID

It is well established that active immunization with tetanus toxoid results in a much greater degree of protection than does passive immunization with tetanus antitoxin.

The immunization schedule followed by the Army consists of administration of two injections of 0.5 ml. dosages of toxoid at least six weeks apart, followed in approximately one year by a third injection of 0.5 ml. of tetanus toxoid. This third dose is not to be interpreted as a booster dose but rather as part of the primary immunization procedure. A stimulating booster dosage in the event of wartime should be administered every four years.

Positive evidence of the effectiveness of an immunization program using tetanus toxoid was demonstrated during World War II with the striking reduction of clinical tetanus occurring among the military. Between December 7, 1941 and January 1, 1946, there were a total of twelve cases of tetanus occurring among Army personnel [3]. Four of these twelve occurred overseas, only one as the result of a battle wound. Six of the twelve patients had received no active immunization. Two additional patients had received the basic immunization of three injections of tetanus toxoid but a booster injection of tetanus toxoid was not given following injury. The remaining four patients had received basic immunization and booster injection following injury. Thus only four cases occurred in soldiers whose records indicated that they had received toxoid as recommended by Army requirements.

These twelve cases of clinical tetanus in World War II compare favorably with a minimum number of seventy cases reported among the fewer Army personnel mobilized during World War I. Moreover, the 2,500 deaths from clinical tetanus reported among the civilian population [11] in the United States during the period of World War II attest to the fact that tetanus is certainly not an extinct disease.

An early experience with antigenic reactions to tetanus toxoid administered by the Army in 1940 to 1941 was soon found to be caused by certain peptones contained in the toxoid. By the latter part of 1942 purification of the toxoids reduced the incidence of sensitivity reactions to toxoid to a negligible number (less than one per 100,000).

While the results speak for themselves as far as the practical merit of the immunologic program against tetanus, additional experimental evidence [1] has indicated that a booster dose of tetanus toxoid administered as late as ten or more years after the initial series will stimulate a protective serum antitoxin level above 0.1 unit per ml.

ANTITOXIN

As the incubation period of tetanus is generally from one to two weeks (although it may vary from one to ninety days), a protective antitoxin level should be effected shortly after injury. In the absence of immunologic protection, tetanus toxin becomes "fixed" in the tissues of the central nervous system. The effectiveness of tetanus antitoxin rests in its ability to neutralize toxin not fixed to tissue. It should be stressed, however, that no amount of antitoxin will prevent clinical tetanus from developing once the toxin has become fixed to the tissues of the nervous system.

The purpose of giving tetanus antitoxin once a tetanus infection has been established is to prevent further absorption of toxin from

the wound and to neutralize any toxin in the tissues or the circulation before it can reach the nerve cells. If this can be given before a lethal dose has reached the nervous system, the patient's life may be saved.

Recurrence of tetanus rarely occurs. However, its occasional recurrence in patients who had previously survived an episode of clinical tetanus demonstrates the failure of adequate immunity to develop following an attack of the disease.

It is controversial just what amount of circulating antitoxin is necessary for protection against clinical tetanus. Recommended protective levels vary from 0.01 to 0.2 units of antitoxin per cc. of serum.

A general pattern of the serum antitoxin level in human beings following the intramuscular injection of 1,500 units of tetanus antitoxin has been established [5]. At twenty-four hours a protective level of antitoxin of 0.1 unit per ml. is obtained, and this will rise to between 0.15 and 0.25 units at four days, falling back to 0.1 unit at seven days. After one week further decline in serum antitoxin levels occurs gradually. A single injection of 30,000 to 100,000 units of tetanus antitoxin, on the other hand, will provide a protective serum level of antitoxin for five to six weeks [9].

COMMENTS

The inoculation of 1,500 units of tetanus antitoxin as a routine measure in the management of trauma treated in the physician's office or the hospital emergency room is a practice which should be reappraised. It is known that clinical tetanus will develop in patients who have been given 1,500 units of tetanus antitoxin at the time of initial treatment of the injury. Interestingly enough, neither the morbidity nor the mortality appears to be lessened by the reception of this so-called "prophylactic" dosage of antitoxin. This would suggest that a dose of 1,500 units of tetanus antitoxin actually may not be sufficient to neutralize the toxin released by multiplying clostridial organisms. In some instances, clinical tetanus undoubtedly results from secondary contamination by clostridial spores after the protective antitoxin level has declined.

The undesirable side reactions that accompany the use of horse serum should not be minimized. In addition to the relatively minor reactions which accompany the hypersensitive state, severe immediate or delayed anaphylactoid reactions occur and may result in death. Histological studies accompanying *in vivo* antigen-antibody reactions invoked by contact with a sensitizing antigen such as horse serum may not be harmless in their immediate or late effects [10].

When an individual has not been previously immunized and clinical judgment indicates tetanus prophylaxis, a dosage of 40,000 to 100,000 units of tetanus antitoxin would appear to be necessary to insure adequate protection against clinical tetanus.

When active immunity to tetanus has been previously achieved with three injections of tetanus toxoid, administration of a booster dose of fluid toxoid at the time of injury will result in a rise in tetanus antitoxin to protective levels within three to seven days [6].

The necessity occasionally arises when immediate protection against tetanus is imperative such as for a wound of several days' duration. Here the combined use of antitoxin and toxoid might be considered. Experimental evidence suggests that combined immunization offers no greater protection than the use of antitoxin alone unless the patient has been previously immunized with tetanus toxoid. However, a patient who has been previously immunized and who receives both tetanus antitoxin and tetanus toxoid will show a satisfactory rise in serum antitoxin titer in one day due to the injected antitoxin and a secondary rise to much higher levels in four to six days due to the injected toxoid [6].

For the small group of patients not previously immunized who are sensitive to tetanus antitoxin, the use of whole blood transfusions from donors with high serum antitoxin levels from active immunization will afford immunologic protection when clinical tetanus is threatening.

Clinical studies [7,8] following the administration of 0.5 ml. of fluid toxoid to individuals immunized over five years previously indicated a rise to protective serum antitoxin levels within four to five days. At seven days, levels of 1.0 units per ml. were demonstrated in most individuals and a hundredfold increase to 10.0 or more units per ml. within fourteen days. While the serum antitoxin levels after toxoid immunization may not be necessarily manifested at a high level after ten years, the individual who has been actively immunized

retains the ability to produce large amounts of antitoxin with extraordinary ability after a booster dose of toxoid. Moreover, the duration of protective levels of serum antitoxin following the use of booster doses of fluid toxoid in the individual who has been previously immunized persists for a much longer period of time.

Since 1941, nearly fifteen million young adults have been actively immunized against tetanus on entry into the Armed Forces. Upon separation from military service, the majority of these individuals have failed to sustain an effective immunity with booster doses of toxoid at appropriate intervals. An effort should be made by the medical profession to encourage their patients who have been actively immunized while in the military service to maintain this immunity with booster doses of tetanus toxoid at five to eight year intervals.

The merit of a civilian population immunologically protected against tetanus infections in the event of an atomic disaster is self evident.

SUMMARY

1. Current concepts of tetanus prophylaxis are reviewed.

2. The advantages of maintaining basic immunologic tetanus prophylaxis of both military and civilian population with booster doses of tetanus toxoid are cited.

3. The use of 1,500 units of tetanus antitoxin in the emergency room care of the ordinary laceration is appraised.

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Brachial Plexus Paralysis Following Administration of Tetanus Antitoxin

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Serum sickness has been estimated to follow the injection of various types of horse serum in about 15 per cent of the cases in which the serum is administered [11]. The possibility that a serious neurological complication may also follow such injections is not generally known. This complication, occurring as a sequel to prophylactic or therapeutic injection, is "horse serum neuritis."

The signs and symptoms of the neuritis most commonly appear at the onset or at the height of serum sickness but may occur without other signs of serum disease. The peripheral nerves are the most commonly involved. In the great majority of cases there is a peculiar anatomic localization in the brachial plexus, principally the fifth and sixth cervical nerves. Fortunately, this condition occurs in only a small number of cases of serum disease. The symptoms are so typical that the diagnosis should not be difficult, but often an incorrect diagnosis is made and delay in treatment results in permanent damage to nerves and muscles.

Localized peripheral neuritis has been mentioned only sporadically in the literature. We wish to call attention to this complication, to emphasize that it may be quite disabling, to review the literature, to consider its treatment, and to report our experience with three cases.

SYMPTOMS

The symptoms of brachial plexus neuritis usually occur within a few hours after onset of the well known symptoms of serum sickness—urticaria, itching, polyarthritis. Characteristically there is an acute onset of severe neuritic pains in the neck, shoulder and arm, the pain being so intense that large doses of opiates are required for relief. Within a few hours flaccid paralysis occurs of the muscles supplied by the involved peripheral nerves. As the pain gradually diminishes the subjective findings of hyperesthesia and muscle tenderness develop. In some cases the pain disappears promptly, but in the usual case dull pains persist for days, weeks or even months. Often the nerve involvement is bilateral and symptoms occur in both upper extremities. Thus, the extremity affected by the paralysis is unrelated to the site of injection of the antitoxin.

Following its onset, the paralysis develops gradually and reaches a maximum within one to four days. Examination reveals that one or more nerves are affected. The nerves involved, in order of frequency, are the axillary, suprascapular and long thoracic nerves [2-7]. Inability to abduct the arm is one of the earliest subjective signs and is caused by involvement of the nerve supply to the shoulder cuff and deltoid muscles which are innervated by the axillary and suprascapular nerves. Other neurological signs present, such as reduced or absent reflexes, sensory loss and later atrophy, involve principally the deltoid and two of the shoulder cuff muscles (supraspinatus and infraspinatus).

PATHOGENESIS

The cause of serum neuritis and the reason why it is most frequently localized to the cervicobrachial plexus are not known. Bennett [2] discussed the theories of various authors including Richardson [13] who thought that serum had a direct toxic action on nerves. Pessin [12] suggested that protein toxins affect muscles innervated by nerves of low chronaxia. Bennett [2], as well as Kennedy [10], Young [16], Allen [1], and Wilson and Hadden [15], believed that a perineural edema produced a compressive paralysis of the involved nerves. Whether or not edematous compression of the

nerve is the mechanism of action, tetanus antitoxin apparently manifests a tissue selectivity for certain peripheral nerves or nerve groups. This peculiar affinity is not explained but the brachial plexus is by far the most common site of involvement.

Other nerves rarely affected are the cranial nerves [*15*], and in rare instances the lumbar plexus [*8*]. Comroe et al. [*3*] reported a case of complete paralysis of the thoracic respiratory muscles and partial paralysis of the diaphragm. This pattern they felt was compatible with involvement of spinal roots from the fourth cervical to the eighth and ninth segments. Their patient had received tetanus antitoxin but had no previous or concomitant symptoms of serum sickness, demonstrating that occasionally isolated nerve involvement is the only sign of toxicity. The patient in our Case 1 had isolated brachial plexus neuritis without other evidence of serum sickness. The diagnosis is more difficult in the absence of symptoms of serum sickness.

INCIDENCE

The most complete review of the literature prior to 1939 was made by Bennett [*2*] who found 115 previously reported cases and added five of his own. He attributed the first accurate case report to Gangolphe [*8*] in 1908. We have been able to find only seven reported cases since 1939: Fischer [*7*] in 1951, Comroe et al. [*3*] in 1951, Mishkin [*11*] in 1949, Thompson and Tombleson [*14*] in 1940, Fetter [*6*] in 1953, and Dickey [*4*] in 1955. We are reporting three cases from our experience, all patients having been hospitalized at Touro Infirmary.

In a discussion of this condition, Dr. Howard Karr [*9*], a neurosurgeon, said that he had observed four cases in office consultation in the past ten years in New Orleans. The complication appears to be uncommon, since no other cases were found in an exhaustive review of the record library files at Touro Infirmary where hundreds of prophylactic injections of tetanus antitoxin are given every year. We feel that the condition may not be as infrequent as this study implies because the correct diagnosis may not always have been made.

PROPHYLAXIS AND TREATMENT

The appearance of isolated cases of horse serum neuritis emphasizes that discretion should be exercised in the administration of tetanus antitoxin. It should never be given routinely. Since there is no known method of preventing serum sickness in susceptible persons, the only sure prophylaxis would be universal active immunization with alum-precipitated toxoid. Until this desirable accomplishment is realized, early recognition of this disabling complication, and early treatment will prevent residual muscle weakness and atrophy in most cases. A history of recent (six to fourteen days) administration of tetanus antitoxin followed by severe neuritic pain in shoulder, neck and arm should suggest the diagnosis. If there is concomitant evidence of serum sickness, the diagnosis is more easily established. It should be mentioned that, although called "brachial plexus neuritis," the condition usually affects only the cephalic portion (fifth and sixth cervical nerves) of the brachial plexus.

The early treatment is largely symptomatic and supportive, consisting of complete rest of the extremity by means of an abduction splint, local heat therapy and analgesics and opiates for pain. Large doses of vitamin B_{12} as well as repeated doses of adrenalin have been given in reported cases. Recently Fetter [*6*] reported the first case of a patient treated with cortisone and ACTH; he felt that these drugs hastened recovery and may have prevented permanent damage to the involved nerves. The patients in our second and third cases received cortisone also, and we believe this is an important adjunct in the early treatment. If the theory that perineural edema is an etiological factor is accepted, then the administration of cortisone may be of specific therapeutic value.

As soon as the acute hyperesthesia has subsided, physiotherapy should be started. This should include electrical stimulation and muscle re-education. Treatment, especially physiotherapy, should begin early because profound atrophy of the muscles can occur during the period when the patient is receiving no treatment.

PROGNOSIS

Thompson and Tombleson [*14*] reported that approximately 80 per cent of patients recover within six months, while 20 per cent are left with muscle weakness and atrophy. Three of Bennett's five patients [*2*] recovered completely without residual handicap; one

patient had marked residual atrophy of the deltoid and one had slight residual deltoid atrophy seven months after injury. Thompson and Tombleson [*14*] mentioned that recovery has occurred as late as eighteen months after injury.

Many writers, including Fischer [*7*] and Bennett [*2*], have warned of the possible medicolegal aspects of this complication. Since the condition is compensable if it follows an industrial injury, tetanus antitoxin should be administered only in cases in which it is clearly indicated. Certainly it should be used in patients with dirty or penetrating wounds, but it should not be given for trivial reasons, or routinely.

CASE REPORTS

CASE I. M. T., a thirty-one year old white mechanic, entered the emergency room of Touro Infirmary on March 10, 1949, because of a puncture wound of the left hypothenar eminence. The wound was cleansed, and the patient was given a skin test dose of tetanus antitoxin in the volar surface of the right forearm. The reaction to the skin test was not remarkable. Therefore, he received the prophylactic dose of 1,500 U tetanus antitoxin in the right deltoid region. He also received 300,000 U of penicillin in the left buttock. No complications resulted and the patient returned to work two days later.

He was apparently well until one week after the injury, when he noticed an area of intense redness about 7 cm. in diameter over the lateral aspect of the lower half of the right arm. This was followed within two hours by aching pains, numbness and weakness of both upper extremities. The pain began in the area of redness and radiated upward over the lateral aspect of the right arm to the right shoulder, across the back of the neck, into the left shoulder and down the left arm as far as the elbow. The numbness was confined to the skin over the lateral aspect of the arm from the elbow to the shoulder bilaterally. There was also a rapidly increasing weakness of the shoulder muscles bilaterally, followed shortly by an inability to abduct the arms. By the following day the area of erythema on the right arm had disappeared, but the pain, numbness and paralysis had become intensified.

Within the next few days the patient consulted a neuropsychiatrist, was hospitalized and received four electric shock treatments which, according to the patient, aggravated his original complaint. He was discharged unimproved.

We then saw the patient in consultation. Individual muscle testing at this time revealed paralysis of both deltoids and of the supraspinatus and infraspinatus muscles bilaterally. All other muscle functions involving the arm and the shoulder were normal and unimpaired. There was an area of anesthesia on the dorsum of the right forearm, but no other areas of sensory disturbance could be demonstrated.

Because of the positive physical findings and in view of the history, the patient was hospitalized in Touro Infirmary on April 22, 1949, with the presumptive diagnosis of toxic neuritis due to tetanus antitoxin. Faradic stimulation on two occasions during the hospital stay revealed no abnormality in the deltoids, supraspinati or infraspinati on either side. There also was no reaction of degeneration. The patient was carefully studied for sensory loss and an area on the dorsum of the right forearm corresponding to the C^6 dermatome was found to be the only one involved. Minor's starch test revealed a relative anhydrosis over the anesthetized area. The patient was supported on supplementary vitamin B therapy and physiotherapy, and was discharged from the hospital on April 29, 1949.

Since his discharge he has been closely followed up at frequent intervals. Electrical stimulation and muscle re-education were carried out three times a week. The patient improved steadily and, at present, he can actively use the shoulder muscles in both upper extremities.

CASE II. F. R., a twenty-eight year old white man, was seen in the emergency room of Touro Infirmary on November 8, 1953, because of "crushing" injury to the distal phalanx of the right index finger. The patient stated that while he was repairing a boat, the finger was accidentally caught between the bottom of the boat and a wooden support. A subungual hematoma was present, and x-ray examination established the diagnosis as an open fracture of the distal phalanx. The wound was cleansed with pHisoderm® and débrided. The subungual hematoma was evacuated and the finger splinted. A skin test dose of tetanus antitoxin was given in the volar skin surface of the left forearm. The skin test was read as negative and the patient received the prophylactic dose of 1,500 U of tetanus antitoxin in the left deltoid muscle.

On November 12th, three days after the injury, the finger was dressed and splinted again. There was no sign of untoward reaction to the antitoxin at that time.

On the morning of November 17th (eight days after injury) a slight urticaria with arthralgia of several joints developed. These responded to antihistamines. About fourteen hours later (2:00 A.M., November 18, 1953) the patient experienced an acute onset of severe pain in the right shoulder, neck and arm. The pain was not relieved by 3 gr. of codeine and 20 gr. of aspirin which the patient took before consulting us. He was admitted to the hospital as an emergency case on November 18,

1953. Rather large doses of morphine and demerol® only slightly reduced the severity of the pain. Twelve hours after admission, the oral administration of cortisone, 300 mg. daily, was begun and continued for three days. The dosage was reduced to 100 mg. a day on the fourth day and continued for several days. The acute pain did not begin to subside until forty-eight hours after hospital admission, and then gradually diminished until the patient was discharged from the hospital.

Twenty-four hours after admission, examination showed inability to abduct the right arm. In addition there was tenderness and an area of hyperesthesia over the right deltoid muscle. Forty-eight hours after admission the pain was slightly less severe, but the patient was still unable to abduct the arm. Also, an area of sensory loss to pinprick appeared over the right deltoid. Supplementary treatment consisted of administration of thiamin chloride, 200 mg. daily, and rest of the arm by means of an abduction splint.

After discharge from Touro Infirmary on November 26, 1953, the patient was seen in the office on November 30, 1953. At this time he still complained of dull pain in the shoulder and arm, requiring codeine and aspirin for relief. Consultation with a neurosurgeon confirmed our diagnosis of brachial plexus neuritis with paralysis of two shoulder cuff muscles (supraspinatus and infraspinatus) and of the deltoid. The patient was referred to a physiotherapist for electrical stimulation and muscle re-education. This treatment was carried out three times weekly for the next six weeks and there was gradual return of muscle function, sensation and muscle power.

The patient was next seen on January 28, 1954, eleven weeks after the initial injury, at which time there was complete return of muscle function. He was last seen on July 7, 1954, eight months after injury, and examination revealed complete recovery with no residual muscle atrophy.

CASE III. L. J. F., a twenty-eight year old white woman, suffered a minor puncture of the sole of the right foot from a pin on April 23, 1957. No local treatment was given except simple cleansing. After a skin test, tetanus antitoxin was administered.

Approximately ten days later typical serum sickness developed, with generalized urticaria, arthralgia, fever and edema. Almost simultaneously she also experienced agonizing pain in the right shoulder, which required large and repeated doses of morphine for relief. She was admitted to Touro Infirmary on May 3, 1957, at which time metacortin® and antihistamines were administered. There was marked improvement and on May 6, 1957, three days later, she was discharged from the hospital.

Approximately ten days later she noticed a protrusion of her right shoulder blade. Examination at this time revealed that she was unable to raise the humerus above the level of the shoulder. When the arm was passively elevated to shoulder level, forward pushing movements could not be performed and the attempt caused a marked winging of the scapula, indicating a paralysis of the long thoracic nerve. All other movements of the shoulder were intact.

When last seen on September 3, 1957, there had been no improvement in the condition.

SUMMARY

Brachial plexus neuritis (paralysis), a peculiar anatomical localization of peripheral neuritis, occurs in rare instances after the injection of tetanus antitoxin [*11*]. About 127 cases of horse serum neuritis have been recorded in the world literature. The severe symptoms, confined to the shoulder, neck and arm, with involvement principally of the deltoid and shoulder cuff muscles, make an early diagnosis possible. The affected muscles (deltoid, supraspinatous and infraspinatous) are involved as a result of impairment of their nerve supply (axillary and suprascapular nerves).

The cause of this neurological complication, as well as of the usually concomitant serum sickness, is unknown. In our opinion the theory of perineural compressive edema is logical, and tetanus antitoxin apparently shows a tissue selectivity for certain nerves or nerve groups.

Early diagnosis and early treatment will prevent residual muscle atrophy and weakness in most cases. Treatment recommended is early administration of cortisone, complete rest of the involved muscles during the acute stage, analgesics and narcotics, local heat therapy, parenteral vitamin B, and early physiotherapy.

Universal active immunization with tetanus toxoid is strongly advised as a method that will reduce the incidence of this complication. In the meantime, discretion should be used in the administration of tetanus antitoxin.

The prognosis for complete recovery is good, but approximately 20 per cent of the patients have some residual muscle atrophy and weakness.

CONCLUSION

Complete recovery, without residual damage, occurred in two of our three cases. One patient

continues to have paralysis of the long thoracic nerve. This syndrome, occurring as a neurological complication of the administration of tetanus antitoxin, should be diagnosed more widely.

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DISCUSSION OF PAPERS BY DRS. ARTZ AND WILLIAMS; ROBB, INGHAM, NELSON AND JOHNSTON; WALL; AND TYLER, KAPLAN AND LEVY

J. H. Schneewind (Chicago, Ill.): I enjoyed the presentation of Drs. Artz and Williams and would like to re-emphasize some of the points they made. Perhaps the case of a fourteen year old girl, mentally retarded, whom we saw at the University of Illinois will help illustrate. She had undergone skin grafting many times, and each time the graft promptly melted away.

We were asked to see the patient by one of the other services who felt that perhaps the adrenal corticoids were at fault; her adrenal glands, perhaps, were not functioning.

We performed urinary studies, and the results were below normal. Upon some reflection we felt the whole problem was nutrition.

By a number of devices we embarked upon what we thought was a rather energetic program of getting protein into her. We used things like the Mead-Johnson tube for night feeding; we had her go to the special diet kietchen where one of the dietitians jollied her along so she would eat everything. In other words we made a big game of it.

I might merely summarize by saying that the patient gained 15 pounds in weight over the course of this program and that subsequent skin grafts took and were successful. This has happened in a few other patients we have seen. We feel that protein intake or sufficient calorie intake, as shown by Drs. Artz and Williams is one of the most important things in treating the chronic burn patient, and certainly equally important in the treatment of acute burns.

J. W. Blunt (Cleveland, Ohio): I think the paper by Drs. Artz and Williams is a beautiful piece of work, but I would like to mention one point. When complications are encountered, I suggest a check of the intravenous tubing through which the fat is given. Most of these tubes are made of vinyl plastic containing additives which are fat-soluble. Over a period of three hours, you can take out much of the additive. After twenty or twenty-four of these infusions the accumulated material is toxic to the liver, and I suggest an investigation of the tubing.

Curtis P. Artz (closing): I would like to say something about the problem of infection in burns. Dr. Connell is discussing the primary problem in the extensive burn—overwhelming infection.

In the management of about 1,000 burn patients at the Brooke Army Medical Center, there were eighty-two deaths. Fifty-three died from what was believed to be overwhelming infection or, more specifically, septicemia. The average size of the burn in these latter patients was 57 per cent, with 39 per cent being third degree.

During that same period septicemia developed in twelve patients who survived. This group was different in that the burns were smaller, 42 per cent, with 27 per cent being third degree. The most predominant organism was the staphylococcus, mostly phage type 3.

I think it is important to re-emphasize the fact that we should hold one antibiotic and not use it routinely. This is true not only in burns but also in all aspects of trauma and surgery. This may prevent the bacteria from becoming resistant to that antibiotic.

I am not sure how we are going to solve the problem of infection in the burned patient. I think emphasis should be placed on trying to keep a clean area and eliminating contamination as much as possible. I think we must study the burned patient

to find out why his mechanisms for resistance to bacteria are not as good as those of someone who is not burned.

Excision in the smaller burn is very advantageous. We have not been able to perform excision on the extensively burned patient and have any greater salvage than with treatment by conventional methods. I do feel it is one avenue that deserves further exploration, and I would encourage people who have an adequate team to perform excision on the extensively burned patient and to study them carefully.

I appreciate Dr. Blunt's comments very much. The tubing should be rechecked to see if some toxic substances are going into the blood stream. I think that as we all use the intravenous fat infusions in large quantities, we will find that a very severe response such as interference with liver function and the coagulation mechanism will develop in an occasional patient. This deserves further investigation, but 12 to 16 units are probably very safe.

Oscar Perry Hampton, Jr. (St. Louis, Mo.): Drs. Tyler, Kaplan and Levy have brought to our attention one of the many complications of horse serum administration. I did want to ask them if they know of any complications as a result of the administration of horse serum other than antitetanus antitoxin. The subject of their presentation points up another reason we should try to achieve something approaching universal immunization with tetanus toxoid. This Association took up the problem of universal immunization with tetanus toxoid as a project a few years ago and, unless I am mistaken, the Committee still exists, but its chairman never comes to a meeting; hence no committee report. The Committee tried at that time to stimulate interest in this problem.

At that time, Dr. Wall, this Committee urged widespread use of 5,000 to 10,000 units of tetanus antitoxin if and when passive immunization is indicated. Again, Dr. Hale of Buffalo made the same plea in a paper before this group a year or two later.

A problem that we are all confronted with daily concerns whether passive immunization is indicated for relatively trivial wounds sustained indoors or within an automobile, for instance. Obviously, tetanus does occasionally develop in wounds which appear relatively trivial. It seems important to point out that tetanus is not going to develop in a wound which is entirely aerobic. If it does not contain dead tissue, tetanus will not develop. Therefore, getting rid of all dead tissue and debris in a wound is a good prophylactic measure. Leaving wounds open also may be an important prophylactic measure; of course one can figure on delayed closure. Other deterrents are antibiotics, but one cannot depend entirely on antibiotics to prevent tetanus.

In the previously unimmunized person with a trivial wound perhaps it would be good practice to use antibiotics, perform good wound surgery, and give a first dose of tetanus toxoid. One need not then wait thirty days to give a second dose of tetanus toxoid. It can be given in seven to ten days with some benefit, and a third one may be given a week later. We can do away with passive immunization in many instances if we try.

There is not time to go into all of the facets of this problem raised by Dr. Wall. I do not believe everyone accepts that the high concentration of antitoxin per milliliter he showed on his chart is required for protection. One-hundredth of a unit of actively produced antitoxin per cubic centimeter will certainly protect, and there is good evidence that one-thousandth of a unit per cubic centimeter, when it is on the uptrend, will protect.

I. W. Kaplan (closing): The condition that Dr. Tyler has presented represents another one of the many complications resulting from the administration of tetanus antitoxin. In two of our three cases the diagnosis was missed by the attending physicians because they were unfamiliar with this complication. In fact, one of these patients had been given shock therapy under a mistaken diagnosis.

A survey in New Orleans revealed that most of the general surgeons, orthopedists and internists were unfamiliar with this complication. All of the neurosurgeons knew of it and had seen one or several cases in their practice over a period of years. The incidence of this complication is difficult to determine because most injections of tetanus antitoxin are given on an outpatient basis. When the complication does occur, it is often missed.

The appearance of isolated cases of brachial plexus neuritis and paralysis emphasizes that discretion should be used in the administration of tetanus antitoxin. We feel that the administration of cortisone will shorten the painful period, but whether it will shorten the period of paralysis we are not able to say at this time.

Homer M. Smathers (Detroit, Mich.): The two papers on the subject of tetanus hinted at possible "selective immunization." One wonders whether such immunization would be upon the basis of the wound or perhaps on a seasonal basis.

The same percentage is found everywhere in the medical literature: there are many more cases of tetanus in the spring and summer. If this were the only basis, then we could certainly by-pass immunization in the fall and winter.

The etiologies of 105 cases reviewed in 1953 from the Detroit Receiving Hospital and Children's Hospital points up the difficulty one would have in deciding on which wound to immunize. In-

cluded in this series are two cases of tetanus following hemorrhoidectomies and two mild cases following vaccination.

In the last five years at Children's Hospital in Detroit there has not been a case of tetanus, whereas we had fifteen cases at Detroit Receiving Hospital. Of the fifteen, five died; four of the fifteen patients had had tetanus antitoxin at the time they were first treated for their injury. This emphasizes the point that Dr. Wall made in that insufficient tetanus antitoxin was given to them, since they all received 1,500 units. I most emphatically agree with the authors of the two previous papers that we must eventually immunize the entire population with tetanus toxoid. There is no reason for any more cases of tetanus then there is for cases of smallpox.

Brooke Roberts (Philadelphia, Pa.): I wanted to mention the point that brachial plexus paralysis may occur quite late. During the last year, in fact, we saw a patient who was admitted with the complaint of pain in the shoulder. It was quite apparent, on examination, that he had atrophy of the supraspinatus, infraspinatus, deltoid and also trapezius muscle on one side, and less atrophy on the other. I had given this patient antitoxin five months earlier because of a puncture wound of the foot. No serum sickness or complications were seen at that time, and I completely missed the subsequent diagnosis. It was because of a rather astute neurologist to whom I referred the patient that it was picked up. The neurologist told me he had seen four such patients with very delayed symptoms involving the brachial plexus.

Brachial plexus involvement may develop many months later, and it is well to keep it in mind if unexplained brachial plexus paralysis is encountered.

Robert H. Kennedy (New York, N. Y.): We have had a directive in my hospital ever since the war in which we stated that all people who had had tetanus toxoid should receive simply a booster dose. The directive says that anyone in the Armed Forces since 1942 shall get a booster dose of toxoid only. We cannot find out anything about the children. The mothers know they have had injections, but we cannot find out whether or not these included tetanus toxoid.

Both of the speakers have remarked that tetanus antitoxin should not be used as a routine in all wounds; that there should be some consideration of when it should be used. While we have a definite directive as far as how it shall be given, the sensitivity test, etc., I have never been willing to write a directive as to which patients with wounds do not need protection by tetanus antitoxin.

I would be interested to know whether these speakers are willing to tell their emergency room men in writing which patients with wounds should receive antitoxin and which not. You will find that the training of these men has been quite different in different institutions. I often see tetanus antitoxin given to the young secretary in a New York office who goes to the water cooler, breaks a glass and cuts her finger. You cannot say that every cut finger should not have it. Should different rules be made for the city and the country, and so on?

I have wished for more than ten years that I could write a directive so that I could cut down the amount of tetanus antitoxin given when we do not know whether tetanus toxoid has been administered. However, I do not know how you can frame a general directive to the emergency room doctor regarding when he shall give antitoxin and when not in every wound he encounters.

John J. Cranley (Cincinnati, Ohio): I would like to ask a question of Dr. Wall. He mentioned that tetanus toxoid and tetanus antitoxin are not additive and he inferred, I believe, that they should not be given together at the time of initial treatment. However, my interpretation of his comments indicates an overlapping of the effective time period for each agent. Does this mean that they should both be used initially?

Jonathan E. Rhoads (Philadelphia, Pa.): I would like to emphasize the point that Dr. Kennedy raised. The transactions of this Association are published. If we imply that the members of this Association do not think that most patients with wounds should have specific protection against tetanus, we are perhaps creating a somewhat dangerous impression.

It was mentioned that there were seventy cases of tetanus in the Armed Forces during World War I. This is a small number, considering the tremendous exposure during those years. I believe the low incidence was achieved entirely with the antitoxin. I do not think the toxoid was available. I believe there were control series in the Armed Forces of some of the other allies in which many more cases of tetanus occurred.

I would think that until we could say with some assurance, and were willing to say in writing, which patients with traumatic wounds should not receive tetanus prophylaxis, it is somewhat unsatisfactory to create the impression that its use should be diminished.

Oscar Perry Hampton, Jr. (St. Louis, Mo.): I want to attempt to counteract what Dr. Rhoads has said, because I am firmly convinced that it is wrong to give all of these people with trivial wounds tetanus antitoxin. There is excellent evidence that if the patient is sensitive to horse serum, the protecting value of tetanus antitoxin is greatly diminished. There is a rapid drop in the concentration of antitoxin in the serum within a

matter of twenty-four or forty-eight hours even if 100,000 units were given as passive protection. Adequate protection against tetanus may not persist for seventy-two hours after the wound was sustained.

Some evidence has been gathered that if a patient has ever had horse serum, then later needs passive immunization, the protection granted will not be sufficient to protect because of rapid elimination. Therefore, why should we continue to give tetanus antitoxin so promiscuously for passive immunization?

Some people doubt that it actually will provide protection against tetanus. The British experience in World War I was eight cases per thousand before the advent of tetanus antitoxin; one case per thousand after the advent of tetanus antitoxin. By these data, it certainly is effective, but is that complete evidence? No! The incidence may vary according to the type of soil where the fighting occurs. Moreover, the character of the surgery employed by the British forward surgeons may have improved a great deal, and this would tend to lower the incidence of tetanus. Can we say that the lowered incidence of gas gangrene toward the end of World War II was entirely attributable to the antibiotics? No. The type of surgery performed on wounds became better. This probably was a very big reason for the drop in the incidence of gas gangrene.

It is true that animals can be protected against tetanus by a passive immunization with tetanus antitoxin, but passive immunization in humans is not without risk. In addition to anaphylaxis, there is some morbidity with serum sickness and, moreover, passive immunization may be less effective or ineffective if a patient has previously been given horse serum. It seems reasonable to state that there should be a real indication before passive immunization with tetanus antitoxin is provided.

I would like to point out quickly how one may meet this problem with trivial wounds in everyday practice. The wounds are thoroughly cleaned and some broad-spectrum antibiotic protection is given. The first injection of tetanus toxoid is administered. The wound and the patient are observed closely. So far we have had no reason to regret this program because no untoward results have occurred. Some three or four weeks after the first injection of tetanus toxoid, another is given and the patient is told that he should receive a third injection about six months later.

Recently we have attempted to provide an active immunization by intracutaneous injections of tetanus toxoid. In animals, Varney has demonstrated that a protecting level of active immunity has been produced within seven days. We were not able to do that in humans. We have been able to obtain .001 units of antitoxin per cc. at the end of fourteen days with intracutaneous injections of tetanus toxoid on the first, fourth and seventh days. Since this is an actively produced antitoxin on the uptrend, this level may be adequate to protect. Definitely a highly protective level will develop by the twenty-eighth day. These data will be published.

CHARLES JOHNSTON (Detroit, Mich.): We carry out immunization on all burns, and when running a large series with a great number of people, in terms of varying experience in judgment and evaluation, we have to have something to go by. There are also legal problems which might arise.

We recently had a patient who died, even though she was tested for sensitivity and received tetanus antitoxin. This raised the question as to whether it was necessary to give all these people all these shots.

The other problem is the toxoid. I think if we could make a little better impression on the public in relation to this, it might make a difference. So long as there is no trouble around, most people do not think of tetanus. Unless they know of a case, they are unconcerned about it.

I recognize that we can talk about the public all we want to, but I wonder how many of you here have had booster shots within the last five years? From your indication, I think it is quite a bit less than half of this audience. When you think of the difference in the population and the information they get, you realize it is one of those things you just neglect.

I have discussed several times that firemen are in a position where they get wounds that are quite dirty at times. Tetanus immunization is left to their discretion, and their discretion is that they do not see any reason for it. That is someone else's problem. I think this is a very good topic for discussion, one we ought to make a little more effort to bring to the attention of people. I think it is just as important to inform the public about the importance of tetantus toxoid as it is to inform them of other diseases such as tuberculosis, cancer and heart disease.

C. ALLEN WALL (closing): We presented these controversial ideas with a view toward stimulating discussion, and I believe we accomplished our end.

There are, in brief, answers to a few questions raised. One, we certainly agree with Dr. Hampton that there is no need for the use of tetanus antitoxin with all acute traumatic lacerations. It was brought up that .001 units of antitoxin per ml. on the upswing would give a protective level. We feel, as Dr. Hampton implied, that the protection is not at the .001 units of antitoxin per ml. level, but that it soon would reach a protective level with a booster dose of tetanus toxoid. You can take a very minute level of antitoxin in the serum

and stimulate it with a toxoid booster and get protection.

In reference to Dr. Cranley's question, we do not feel that combined immunization is preferable to the use of toxoid alone, or antitoxin alone, for very definite reasons. You see, there is generally little reason for a protective level within twenty-four hours after injury. Granted, an occasional case of tetanus has been reported in the literature with an incubation period as short as one day. The majority, however, are in the five- to twenty-one-day bracket. In a previously immunized patient, protection will be afforded within three to four days with a booster dose of toxoid. There is little benefit derived from additional tetanus prophylaxis with antitoxin. On the other hand, a patient who has not been immunized will receive no immunologic protection from a single 0.5 cc. dose of fluid toxoid. Combined immunization should be reserved for that occasional previously immunized patient with a wound considered as a potential breeding ground for anaerobic bacteria and in whom there has been a delay in tetanus prophylaxis. The morbidity with a booster dose of toxoid is nil; that with a prophylactic dose of antitoxin may be considerable.

As far as Dr. Kennedy's question is concerned, eliminating the use of tetanus antitoxin may present a medicolegal problem. One might speculate on the outcome of a suit concerning a patient not given the antitoxin in whom tetanus developed. The present controversy revolves around the effective protection afforded by the usual "prophylactic" dosage of 1,500 units versus the alleged risk entailed with its use.

In summary, let me restate our position. We feel that an attempt should be directed toward continuing immunologic protection of the previously immunized population with tetanus toxoid boosters every five to ten years. There should be no hesitation in administering a booster dose of fluid toxoid to previously immunized patients at the time of injury. For the non-immunized patient, let us first evaluate the wound as a "tetanus potential," weigh the advantages of giving tetanus antitoxin against the possible morbidity entailed, and then give an adequate dose. We do not feel that 1,500 units is an adequate dosage. We recommend a minimum of 10,000 units.

L. Terrell Tyler (closing): I would like to thank all of the discussers for their comments and questions.

In answer to Dr. Hampton's question, there have been two cases reported following diphtheria antitoxin.

Also, I want to thank Dr. Hampton for his suggestion of treating the wound with antibiotics and giving the first dose of toxoid. This method appeals to us very much.

Dr. Wall mentioned the possible medical-legal aspect of this condition, of which several writers have warned. Brachial plexus paralysis is compensable if it follows an industrial injury. Therefore, for that reason, it should be administered only in cases in which it is clearly indicated. We feel that it should be used in patients, certainly, with dirty or penetrating wounds; but it should not be given for trivial reasons or routinely, as has been emphasized by Drs. Wall, Stack, Cranley and Hampton.

The complication appears to be uncommon, but we feel that the condition may not be as infrequent as this study implies, because the correct diagnosis may not always have been made. We hope this report will call attention to a very serious complication of tetanus antitoxin administration, and thus encourage discrimination in using it. Our plea is the need for universal active immunization with tetanus toxoid.

Rudolf J. Noer (Louisville, Ky.): Drs. Robb, Ingham and Nelson have given us a graphic demonstration of the great virtue of blood replacement rather than vasoconstrictors in the treatment of shock. It is interesting to note how our profession, since the beginning of time, has searched for magic drugs and preferred them to good, basic principles.

Many years ago, Dr. Norman Freeman, studying circulation in the finger, called attention to the danger of using vasoconstrictors in shock. Gradually people gave them up. However, with the advent of the new drugs, pushed by the drug houses, of course, we find people today turning again to vasoconstrictors when the basic danger to the patient is coming from his diminished circulating blood volume.

I was particularly impressed with the relative avascularity of the bowel wall, even more than the constriction of the largest vessels. I think it is important that we never forget that what we are ultimately interested in is not what the sphygmometer shows, but what is going on in the tissues of the patient in shock. I think we must be very grateful to these men for showing this so graphically. It is incumbent on all of us to impress the house staff and others with the fact that there is no substitute for blood replacement when the patient's difficulty is diminished circulating blood volume.

Campbell Gardner (Montreal, Can.): Dr. Noer has mentioned the first part of what I was going to say. Certainly, with all the talk about the different aspects of shock, both theoretical and practical, it must never be forgotten that in shock due to blood volume deficit, and especially due to whole blood volume deficit, the treatment of choice is transfusion.

Do drugs like levophed® have a place? Perhaps

this will be shown by continuation of the same type of studies Drs. Robb, Ingham and Nelson have been performing. If this drug has a place, one would guess it is at the other end of the treatment program—at the close not the beginning. It does have a place, I think, in extracellular fluid loss in types of hypotension in which we replace as much fluid as we dare (not too fast for fear of inducing heart failure and pulmonary edema) but still do not have a sustained circulation.

I find that levophed clinically, at least, may tide one over (used sparingly and carefully) after a proper attempt has been made to replace circulating blood volume, but not before.

One of the things that has disturbed us since these drugs were introduced is the tendency of the resident staff and others to resort to levophed at the first sign of a drop in blood pressure without checking the possible cause of the hypotension.

We need more accuracy in ascertaining the primary lesion which is causing hypotension and treating it with one of the specific measures at our command.

In the role of autonomic drugs, there is another side to this coin which we have been studying in our laboratory at McGill—the use of sympathicolytic drugs, not only in prophylaxis but also in the therapy of shock states.

We have found, and it is most interesting in view of the work presented, that if a dog in complete shock has a decrease in mesenteric vein blood flow to below 30 per cent of normal, chlorpromazine, administered in small intravenous doses repeatedly after the induction of profound shock, will reverse this depression of mesenteric blood flow in an upward direction, in spite of the fact that the mesenteric arterial and general systemic pressure remains in the neighborhood of 30 ml. We do not know how the drug acts. It probably is opening up channels which the normal, so-called spastic mechanisms have closed down. This corresponds with an improvement in survival in the animals in which chlorpromazine was used, but we are not in a position, as yet, to tell ourselves or anyone else how to use chlorpromazine in the treatment of shock.

Like levophed, any of these autonomic drugs used intravenously are weapons, both explosive and dangerous. A little too large a dose administered at the wrong time can be rapidly lethal.

Nevertheless, as study media, and perhaps therapeutic equipment later, they have stimulated a great deal of interest in the gut circulation as a possible local area which we have ignored a little too much in our attempts to understand the various reasons behind the reversibility of the shock picture.

JOHN J. CRANLEY (Cincinnati, Ohio): I, too, was profoundly impressed by the picture of Drs. Robb, Ingham and Nelson and the light it throws on another complication in the use of norepinephrine.

During the past three years we have seen six instances of slough of the skin of the lower extremity following the use of norepinephrine injected at the ankle. We had the opportunity of treating one of these patients who had almost complete destruction of the skin and subcutaneous tissues of the medial aspect of the leg. It was necessary to excise this large slough and insert a split-thickness skin graft.

The mechanism by which such a large slough occurs following injection of norepinephrine into a vein is not clear. Possibly some of the norepinephrine is carried backward in the vein to the capillaries, and there its intense vasoconstricting action causes ischemia of the tissue.

AMBROSE H. STORCK (New Orleans, La.): Is it advisable to use these drugs, as compared with using blood, when shock is not associated with a particularly large blood loss? It has been my impression that whole blood rather than blood pressure–raising drugs often should be used even when there has not been much blood loss.

JOSEPH E. HAMILTON (Louisville, Ky.): I was very much impressed with the paper of Dr. Robb and his colleagues, and would like to ask one question. What might happen in animals on prolonged levophed® administration who do not have diminished blood volume, or in those whose blood volume has been restored? The reason for this question is that we have had several debilitated and poor risk patients who remained in shock after major surgery despite transfusion, even to the point of overcorrection of their estimated blood volume. For two to three days they were normotensive only while on nor-epinephrine drip, and yet at the end of this time they went on to recovery.

HERBERT J. ROBB (closing): I would like to thank the discussers for their consideration of the paper concerning vascular changes in shock. Dr. Noer's discussion is particularly appreciated for I know he has had considerable experience in observing the changes that take place in these capillaries during acute distention of the bowel, and is well acquainted with the problems involved in photographic reproduction.

The changes occurring with the use of vasoconstrictor drugs may seem obvious. Vessels constrict, the vascular system is smaller and the blood pressure is elevated. The other consideration, however, is that blockage of blood flow by arteriolar constriction in vasoconstrictor-treated hemorrhagic shock leads to relative cessation of blood flow in the capillaries. One can observe cyanosis develop on the venous side and interpret this as tissue anoxia, because the rate of circulation

has been diminished. This I realize is contrary to what you might expect when there has been an elevation of blood pressure.

Drs. Stack and Hamilton wondered if we had made observations in animals who did not have blood loss. This is a study of treatment in hemorrhagic shock. Here changes are extreme and great enough to photograph. When no blood loss has occurred, tremendous elevations of blood pressure would develop before similar microscopic changes could occur. A vasodilator, arfonad,® has been used to produce changes which may develop in shock without blood loss. The arteries constricted and the veins dilated.

In summary, we have tried to demonstrate what happens in blood vessels in response to shock and how they seem to compensate for blood loss. It is our impression that following the use of these drugs, the blood vessels were unable to compensate normally to blood loss. They were unable to maintain adequate blood pressures as they would have had vasoconstrictor drugs not been given first. In other words, if the animals or our clinical patients were given vasoconstrictor drugs first, the amount of blood which should have returned their pressures to normal and maintained them there was grossly inadequate and insufficient to treat them.

Necrosis of Skull and Long Bones Resulting from Deep Burns, with Evidence of Regeneration

DONALD M. GLOVER, M.D., *Cleveland, Ohio*

MAJOR bone necrosis has occurred three times in approximately 1,500 hospitalized burn cases, in the experience of the author at St. Luke's Hospital, Cleveland, Ohio. The mechanism of production is ischemia due to coagulation of surrounding soft tissues and periosteum by the burning agent. Treatment is often complicated by the fact that other severe injuries are present.

The following three cases illustrate the problems involved and provide the basis for a discussion of methods of treatment.

CASE REPORTS

L. B., a Negro steel worker forty-eight years of age, was severely burned about the face and frontal region when he fell into a pit of molten slag. Subsequent information seemed to indicate that he was unconscious from an epileptiform seizure when he fell. Immediately a hard, dense eschar developed over the forehead and face, and there were minor burns about the chest, neck and hands. When first seen by the author approximately two months later, there was complete denudation of almost the entire frontal area and nasal bones. There were also deep burns of the tip of the nose, both cheeks, lips and chin, which were granulating.

Since the margins of the exposed frontal bone had not yet demarcated, it was assumed that bone necrosis involved only the outer table and that circulation was still present in the diploë between inner and outer tables. Accordingly, the exposed bone was drilled with many holes, about 3 mm. in diameter and 10 mm. apart. Free bleeding from the diploë encouraged us to believe that most of the frontal bone might revascularize. This procedure was performed without anesthesia. A few days later large split-thickness skin grafts were applied to the granulating areas of the cheeks and outlay grafts to the commissures of the mouth. One month later additional free grafts were applied to the eyelids to overcome ectropion, and to the lips.

Two months after the perforations had been made in the frontal bone, a good layer of granulation had pretty well covered the outer table of the frontal bone, and the nasal bones had likewise revascularized without assistance. Accordingly, split-thickness grafts were placed over both areas after first removing a few bone spicules and leveling the granulations. All grafts healed well enough to provide a satisfactory cover, and the patient was sent out from the hospital for a period of ambulatory rehabilitation prior to continuing extensive soft tissue reconstruction.

About one year after injury a bilateral cervicothoracic flap was prepared in stages and swung to the nose, and pedicles were reversed to form full-thickness skin for the supraorbital ridges and lips. It took more than a year to complete these procedures. The areas of original denudation were now covered with stable skin, but the cosmetic effect was far from ideal. (Fig. 1.) Additional procedures were planned to improve his appearance two years later, but just prior to the time of the planned readmission to the hospital the patient died suddenly in another city from what was assumed to have been a cerebrovascular accident.

V. S., a forty-two year old electrical lineman for a power company, was severely injured when he came in contact with a high tension line carrying 7,500 volts (resistance not known). He suffered deep burns about the scalp, forehead, right eye, hands and right foot. When first seen by the author six months later, the crown of his skull was completely exposed, with exudate around the margins where sequestration was apparent. The exposed bone included the parietal bones, part of the occipital, and the right side of the frontal bone down to and including the supraorbital ridge. The right eye had been enuclated. Two fingers of the right hand and one on the left had been amputated;

FIG. 1. Necrosis of the frontal bone and extensive burns of the face from molten slag, after partial reconstruction with free and pedicled grafts.

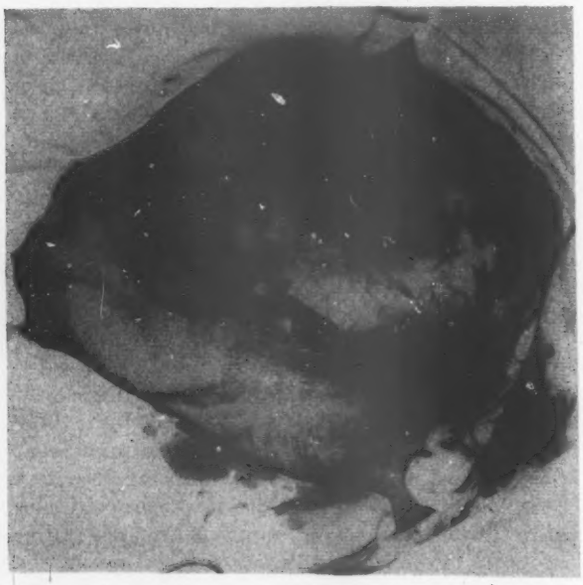


FIG. 2. Full-thickness necrosis of the skull and frontal bone due to an electrical burn prior to removal of the sequestrum. When removed a split-skin graft was applied over exposed dura and margins of inner table.

remaining fingers were contracted in flexed position. There was an open ulcer in the healing scar on the plantar surface of the right foot. (Fig. 2.)

After a few days of surgical hypochlorite dressings and systemic antibiotic it was possible to separate and lift off the entire mass of necrotic bone. About the margins the inner table was viable and granulating, but the entire central area, about 38 sq. cm. in diameter, was occupied by dura covered by a thin layer of granulations. A thick split graft was applied immediately over this surface and fixed in position by fine silk sutures tied through and around a block of sponge rubber

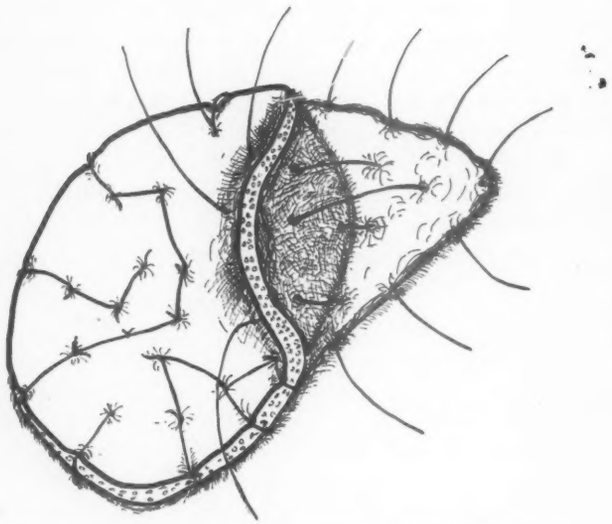


FIG. 3. Application of the sponge rubber method of fixation of free skin graft. The graft is sutured to the recipient area with many fine sutures. The ends of the sutures are left long and are subsequently passed through and about a block of sponge rubber (about ½ inch thick) which has been cut to fit the defect accurately. A single layer of xeroform® gauze is interposed between the graft and the sponge rubber. When tied to each other the suture ends fix the sponge rubber securely to the graft and its bed, so that slipping is impossible.

cut to fit the defect. (Fig. 3.) The graft healed promptly and was comfortable from the first week. This was not, of course, ideal coverage for the dura and underlying brain, but the size of the defect precluded the use of scalp flaps and the patient refused to consider the tedious process of migrating an abdominal flap via the wrist to the scalp. Without such a flap, insertion of bone grafts into the bone defect was out of the question.

After two years there had been sufficient regeneration of bone from the inner table of the skull so that the dura was stabilized, and visible pulsation of the brain was no longer obvious. The patient had decided to wear a baseball cap with metal interliner for protection of the brain rather than to have additional reparative procedures. Other incidental plastic procedures employed during the earlier interval of treatment had included: (1) application of a split-thickness graft to the sole of the right foot; (2) multiple Z-plasties and free grafts to the contracted fingers aided by rubber band traction splinting; (3) a pedicled flap from the right arm to the forehead and supraorbital region.

C. T., a twenty-eight year old power company lineman, made contact with a high tension conductor with his left forearm, grounding the current through both lower extremities. He suffered deep burns of the dorsal aspect of the left forearm, the medial and lateral aspects of the left ankle and foot, the calf of the right leg and the medial aspect of the right ankle. When the dense eschar over the proximal half of the dorsal aspect of the forearm separated, it was obvious that the bellies of the extensor and supinator muscles, and the radial nerve supplying them had been destroyed, and about 8 cm. of the proximal radius was exposed and avascular. At this time split-thickness grafts were applied to the remaining soft tissues about the exposed radius, and the burns of the lower extremities were similarly grafted.

The bone sequestrum separated slowly and was removed about six weeks following the injury. At the same operation an abdominal flap, which had been prepared at the previous operation, was applied to the remaining soft tissue defect in the forearm. Consideration was given to the likely necessity of placing a bone graft to bridge the defect in the radius; but since a 1 cm. wide strip of medial periosteum had been preserved at the time of the sequestrectomy, it was elected to await evidence of bone regeneration. Serial roentgenograms soon showed such satisfactory restoration of the radius that thoughts of bone graft were abandoned. (Figs. 4 and 5.) By the end of two years the upper end of the radius was completely reconstituted. After plastic procedures aimed at partially restoring the lost extensor and supinator mechanisms of the wrist and fingers, the patient was able to return to his former employment, actually on a better job.

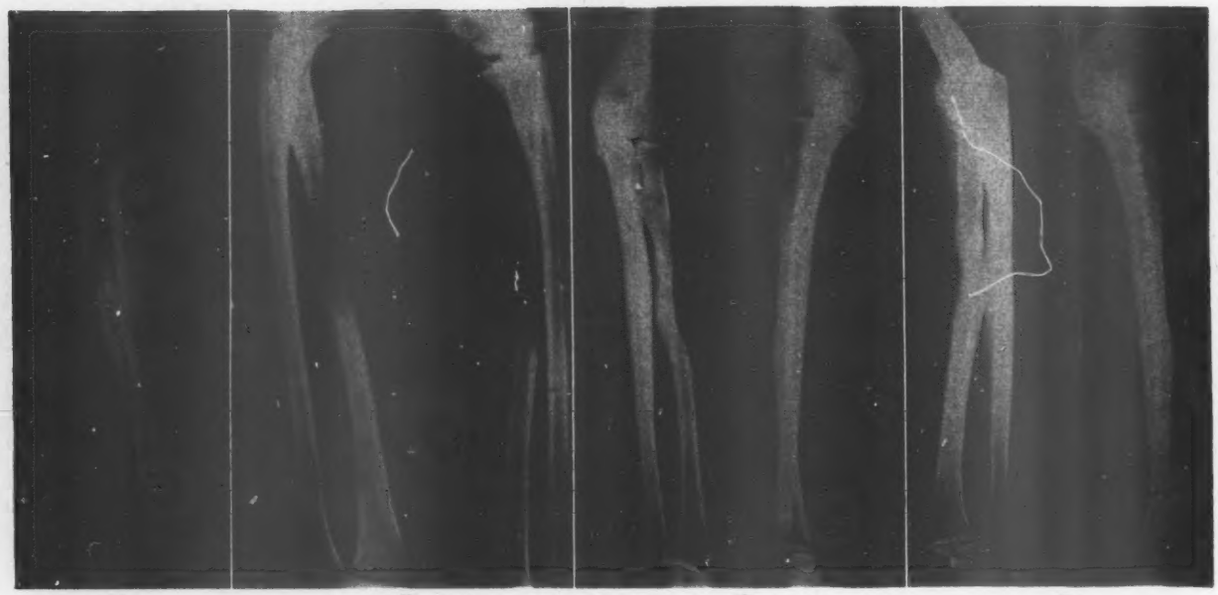
During the period of early bone healing the wrist had been supported by a light aluminum splint, with rubber band traction to the fingers designed to support wrist and hand and to supply resistance to the normal flexor muscles. This mechanism favored maintaining mobility of all joints. The patient actually returned to work first wearing

FIG. 4. Appearance of the forearm after removal of the full-thickness sequestrum of the radius and covering the soft tissue defect with an abdominal flap and free grafts.

the aluminum splint without finger attachments. During this period of activity the proximal stumps of the extensor muscles had recovered function and had hypertrophied. It was then possible to utilize remaining fascia and scar in the forearm to bridge partially the gap between the stumps of the extensors and their tendons proximal to the wrist. With additional hypertrophy of muscle stumps enough strength was obtained to support the wrist in mid-dorsiflexion and to extend the distal phalanges of all the fingers to within 45 degrees of the normal range. Abduction of the thumb was still weak. The additional strength was sufficient to make the splint unnecessary. We were at first somewhat doubtful if his forearm and hand would be strong enough to support him safely in pole climbing, but he soon convinced us of his ability to do so. After a year back at work and a fishing trip to Canada he concluded that pulling in heavy fish all day was harder on his injured arm than his regular occupation. He returned to work happily to rest up for his next fishing trip.

COMMENTS

Primary treatment of the burn has little influence on the incidence of bone necrosis. Factors which are more important are the causative agent of the burn, duration of the heat and the anatomic region affected. By far the most common accidental cause is the passage of electric current of high potential, the next in order of frequency being exposure to molten metal or super-heated liquids. In the



5A 5B 5C 5D

FIG. 5. Necrosis of a full-thickness section of radius. Serial roentgenograms showing complete regeneration: A, dead bone separating prior to removal. B, periosteal bone beginning to form two months after removal of sequestrum. C, regeneration of bone at two years. D, practically complete reconstitution of the radius at thirty months following injury.

latter category might be cited the case of a young bakery worker who had a grand mal epileptic seizure, falling unconscious with his arm suspended in a vat of hot grease. The resulting burn caused complete ischemic necrosis of the entire forearm. The unconscious person is not protected by normal reflexes which might limit his exposure to the burning agent, and is therefore more likely to receive deep burns. Bones which lie close to the cutaneous surface are particularly likely to be damaged by burning agents, which explains the preponderance of cases of necrosis of skull among reported instances of injury of this type.

Immediate excision of small, deep electrical burns is an effective method of treatment, but not in regions where bone is subcutaneous, since in the latter instance excision of soft tissue may expose bone, leading to necrosis which might not otherwise occur. Other methods of treatment have little influence upon the fate of bone.

Of some interest is the difference in behavior of bone which has been damaged by other burning agents from that which has been injured by radium or x-ray radiation. Burns due to heat or passage of electrical current cause almost immediate coagulation thrombosis of nutrient vessels of the periosteum; the resulting destruction is sharply limited and efforts at repair begin almost immediately. With burn effects of this type, some degree of bone regeneration may be expected. In contradistinction, radiation produces diffuse perivascular infiltration and thrombosis which is progressive with the passage of time [1]. As a result radiation necrosis is progressive and proceeds relentlessly to an extent of destruction which initially seemed unlikely. These differences naturally influence treatment. In burns of the first category, reconstructive procedures may be instituted as soon as the dead bone is removed, including bone grafts when indicated. With radiation bone necrosis, on the other hand, bone grafts are not employed with confidence until two or three years have elapsed after sequestration seems complete.

The cases described herein are illustrative of the capacity of bone to regenerate following acute burns. The third case (patient C. T.) demonstrated a degree of regeneration of a long bone from a narrow strip of periosteum that is rarely seen.

It is obviously an advantage to cover bone defects with full-thickness skin of good quality, for which purpose adjacent scalp flaps provide the best source of skin for covering skull defects [2,3]. In some instances, however, when

local scalp flaps are not practical (as in the second case cited), or when other defects have prior claim on donor areas (as in the first case), expediency dictates the use of free grafts. Not infrequently they are permanently satisfactory from a functional standpoint, if not from that of appearance. If a bone graft is required, a well vascularized skin flap is mandatory to aid in providing blood supply to the graft. Most skull defects should be filled in by bone grafts for protection of the brain and for better contour. In some instances, as in the cases described herein, bone regeneration may be sufficient to render them unnecessary. Damage to the brain is not infrequent in deep burns with loss of skull, but none existed in these cases.

The sponge rubber method of fixation of free grafts (Fig. 3) is particularly useful in difficult areas, as in the scalp, face, neck and axilla. The long ends of the sutures carried through and around the block of sponge rubber when tied, ensure holding the graft flat and in contact with all parts of the recipient area. It is thus virtually unnecessary to apply cumbersome covering dressings which are frequently employed with other methods. Having used this type of fixation for the past twenty years and taught it to a generation of residents, we regard it as nearly foolproof. This method was described in a previous communication [4].

CONCLUSIONS

Major bone necrosis due to deep burns occurs infrequently but poses special problems in management when it does. Some of these are discussed and illustrated.

In such necrosis due to fire or electrical burns some degree of bone regeneration may be expected, in contradistinction to radiation necrosis where progressive destruction is almost the rule.

An unusual case of complete regeneration of a section of the radius, following full-thickness bone loss due to an electrical burn, is described.

Free skin grafts may provide a satisfactory cover for full-thickness or outer table bone loss of the skull, but pedicled scalp flaps are preferred when practical.

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The Control of Infection in the Severely Burned Patient

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INFECTION superimposed on the severe trauma of an extensive burn is still a major obstacle to the patient's survival. To prevent and/or treat this phenomenon requires that the attending surgeon or team be fully aware of all the facets of asepsis, surgical drainage, wound bacteriology and rational antibiotic therapy. It requires a determined teaching program that will frequently recall many of the basic surgical principles relating to infection that have been dimmed by the thoughtless and irrational prophylactic uses of antibiotic agents. Many competent authorities have seen and challenged this abuse over the past years [*1–3*], but a routine check of patient charts will reveal to what extent they have gone unheeded. It is only when the bacteriological survey returns with a report that the patient has a staphylococcic or coliform infection and that the organism is resistant to all available antibiotics that we must stop and reconsider.

In the seven-year history of the Burn Center at St. Vincent's Hospital in New York City, infection and its sequelae have been our most formidable obstacle in that group of burn patients we now classify as salvageable. Infection has accounted for fourteen deaths or 73 per cent of our total mortalities. The remainder succumbed because of overwhelming burns, pulmonary burns or, in the case of two patients, overhydration. The aforementioned results will be duplicated in a study of reports from most major burn centers.

In this paper I will discuss the principles we have set up to prevent infection and the regimens we have found to be most successful in combating it.

Infection may occur at any time in the interval following extensive thermal injury until the wounds are healed. In many instances the patient may arrive in the hospital shortly after injury and in a matter of hours have a febrile reaction in spite of adequate therapy. In a few instances we have obtained positive blood cultures at this time. Studies by Price [*4*], confirmed clinically by Artz [*5*] and our own group [*6*], indicate that organisms may be collected from the regional lymphatics and blood stream shortly after scalding. The use of open or occlusive dressing technic did not influence this phenomenon, as the primary source of the invading organisms is from the partially devitalized skin surrounding the periphery of the wound. Thus in this instance prophylaxis is impossible to achieve but therapy is directed at the resultant bacteremia by the early use of antibiotics in bactericidal concentrations. Thus on admission all hospitalized burn patients are scheduled for a three-day course of broad-spectrum antibiotics. At the end of three days the antibiotics are stopped unless otherwise indicated. We have utilized parenteral penicillin 600,000 units and streptomycin 0.5 gm. every eight hours for this regimen, as the organisms most frequently encountered are gram-positive cocci. Furthermore, tetanus antitoxin 6,000 units or tetanus toxoid are given depending on whether the last toxoid booster dose was received within two years.

To complete the emergency dressing room prophylaxis our attention is directed to the burn wound. The wounds are gently lavaged with large quantities of water and pHisoHex.® Then all blisters and necrotic debris are aseptically removed. All flexion creases of the extremities and circumferential lesions of the trunk are covered with a non-adherent dressing such as adaptic,® and a large, absorbent dressing is secured to prevent chafing.

The patient is then transported to the burn

room. We have not found it practical to set up a sterile air room as reported by the English and French. The room is screened, the floors are dressed daily with a non-skid oil and personnel traffic in and out of the room is carefully regulated to a minimum. All personnel don mask, cap and gown on entering the room. At each bed there is a water basin with pHisoHex for washing and disinfecting the hands before touching and after leaving the patient. All instruments or utensils employed in the care of the patient are sterilized and are not indiscriminately left about. This reutilization of principles established by Lister, Schemelweiss and Pasteur in the present age of antibiotics is based on very elementary findings.

The portal of entry for bacterial invasion is the open wound area. On the dry eschar organisms are very inactive and will probably become dormant or die. However, once the eschar or crust undergoes cracking or liquefaction, the air contact contaminants have a nidus for propagation. These air-borne organisms are not routinely dangerous unless they come from special sources. The most common sources of dangerous pathogens are from the nursing and physician attendants.

In a recent study duplicating one we performed two years ago we cultured the scissors, the fingernails and the noses and throats of our surgical nurses, house staff and attending physicians, as well as the burn patient and his visitors. The results indicated that our hospital staff had a high carrier rate of staphylococci, both hemolytic and non-hemolytic, and in over 90 per cent the organisms were found resistant to all the antibiotics routinely used on the service. On the other hand, the patient, family and other adult visitors had a much lower incidence of staphylococci and in over 70 per cent the organisms were sensitive to the usual spectra of antibiotics. In the majority of our severely infected burned patients the organisms recovered from the blood were identical with those inhabiting the wound area. In two cases in which klebsiella was responsible for septicemia, a similar organism was found in the nose and throat culture of the attending nurse.

In order that we might have a suitable reserve for serious infections we have prohibited the routine use of a selected number of broad-spectrum antibiotics. Since we have set up strict regulations governing antisepsis and antibiotics, the number of severe, unresponsive infections has materially decreased.

Septicemia. Septicemia is still the most important cause of death in the severely burned patient. It may occur at any time during the course of treatment of the patient but usually occurs during the first twenty-one days. In this period the usual organism cultured has been the hemolytic streptococcus or staphylococcus. Débridement of the eschar or traumatic changes of dressings are usually responsible for breaking down the host's inflammatory tissue barrier. When invasion occurs in the later stages of treatment prior to successful skin closure of the open wounds, the blood cultures will usually reveal gram-negative rods, either coliforms, pyocaneus or proteus. These organisms will usually be found resistant to all antibiotics previously given to the patient and in many instances resistant to all antibiotics routinely used on that floor in the hospital.

In many of the patients when neglect or secondary disease processes have seriously delayed skin replacement the granulation tissue barrier is congested and semi-necrotic, and its impervious nature is destroyed. Clinically, the patient has a prodromal course of forty-eight to seventy-two hours with a spiking febrile reaction accompanied with chills and a rapid pulse. The temperature finally becomes an elevated plateau. The stress reaction may fail at this point and hypotension, vomiting and delirium ensue. Inspection of the wounds reveals no sign of graft take and a pale, unhealthy appearance to the granulation tissue. If this state is not quickly reversed, the patient will rapidly succumb. This is especially true in the extensively burned patient, the child and in the aged group. We have tried to combat this with intravenous antibiotics, fresh whole blood, pressor solutions, cortisone and cortical extracts. Wet drainage of the open wound area is instituted. At autopsy numerous abscesses will be found in the liver, lungs, brain and kidneys. In our last fatality we gave intramuscular varidase® with concomitant heavy antibiotic therapy, but the metastatic abscess cavities were intact at autopsy.

In attempts to prevent this complication and its sequelae we have started débridement within the first two weeks after injury with early skin replacement. Thus while we reinjure the patient with débridemented skin grafting, he can usually tolerate the added stress at this

time better than if allowed to progress into the third or fifth week with open dirty wounds which are actually parasitic in their effects on the metabolic state of the patient.

We have been experimenting with numerous proteolytic enzymes to débride the patient atraumatically® and thus reduce the stress and opportunity for bacterial invasion. For maximum efficiency the enzymatic agent must act rapidly and not injure the granulation tissue—inflammatory layer underlying the eschar. We speak of rapidity because the proteolytic effect on the wet, contaminated, necrotic tissue occurs under dressings and in the presence of the patient's body heat. Thus in effect we have a large superficial abscess. The dressings must be changed frequently so that drainage is maintained, fresh enzyme can be applied and observations made as to the proper time for grafting. To date we have found that a ficin extract called debricin* has been the most effective.

In a number of deep burns we have excised the burned area immediately with primary skin grafting and have had wonderful results. In most instances the patients leave the hospital within two weeks after injury. In this group we have had no infection. However, we have not utilized this procedure in burns that in continuity involved an area of over 15 per cent of the body surface.

Granulating Wounds. The granulatiug wound is a contaminated wound that has an extraordinary protective barrier to bacterial invasion. All granulating wounds are treated with occlusive dressings that provide adequate drainage. The granulating wound, however, is not to be neglected. If it is 1 or 2 cm. in diameter, it will usually epithelize if kept from excessive proliferation. The epithelization of a large wound is slow and the scar epithelium is very friable. Thus if a larger area is involved or the wound is over a flexion crease, it should be rapidly prepared for grafting. When over a joint area the constant motion is such as to break down the barrier repeatedly. These repeated wound insults produce inflammatory reactions and serious defunctioning wound contractures occur. When preparing the granulating wound for skin grafting the patient received antibiotics for two days prior to surgery and for three days following surgery. The wound is carefully débrided of residual slough and a non-adherent contact dressing is placed on the wound. An absorptive dressing is firmly secured over the wound for forty-eight hours. At surgery the dressing is carefully removed and the skin grafts applied either as thin perforated sheets or postage stamps depending on the amount of exudate. The wound is then dressed as before operation. If the exudate is heavy, a soft, perforated catheter is inserted in the overlying dressings and normal saline is instilled every few hours to promote drainage. If this is not carefully carried out, the accumulation of purulent exudate will liquefy the freshly grafted tissues. Oversoaking should also be avoided to prevent maceration of the grafts.

In a report discussing the control of infection in the burn patient a warning is needed concerning the large partial thickness or deep second degree burn wound. If this wound becomes infected, suppuration can result in the conversion of the wound to a full-thickness lesion in a few days. We believe from our previous experiences with the pressure dressing regimen that this phenomenon occurred much more frequently than supposed. We allow the serious discharge of the partial thickness burn to dry out as a crust and to remain intact for five to seven days unless signs of a purulent reaction occur. At the end of a week the crust is soaked with a debricin or varidase® solution to which the patient's serum has been added. The crusts are readily dissolved, leaving a clean epithelized wound. If signs of an infective process under the crusts are found prior to this time, the enzymes are used immediately. The partially epitheiized wound is then kept moist under occlusive dressings as described heretofore until healing has occurred. In many instances the foregoing description may be applied to the infected donor site. The presence of infection in donor site wounds, especially if only a few are available in the extensively burned patient, can be fatal, for in this burn group it is often necessary to use the same donor areas repeatedly. This tragic occurrence, while it may not always result in death, will require expensive therapy, prolong hospitalization and produce additional scarring.

CONCLUSION

In this report we have outlined a number of important facets that will help in the control

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and treatment of infection in the seriously burned patient. It has been shown that the threat of overwhelming infection constantly stalks the burned patient from the moment of injury until the time his wounds have epithelized. We have stressed that while prevention is tedious and necessitates a constant educational program, it will help reduce the mortality rate in a burn unit. We have outlined various aggressive attacks for those patients when infection becomes established. Rational therapy in extensively burned patients requires a good bacteriological laboratory, a separate unit for treatment, and a burn team of men who among other things will be constantly aware of the role of infection in these seriously injured patients.

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Present Evaluation of the Syme Amputation

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DR. James Syme, Professor of Clinical Surgery, University of Edinburgh, described the Syme amputation in 1843 in the *London and Edinburgh Monthly Journal of Medical Science* in a publication entitled "Amputation at the Ankle Joint" [17]. In this he records the successful outcome of his treatment, one year previously, of a case of suppurative disease of the tarsus (probably tuberculosis) by disarticulation of the foot at the ankle. The heel flap was deliberately preserved and was used to cover the end of the tibia but without suture of the incision.

By 1846 Syme had published five articles on this new amputation and by this time he had modified the amputation by removing the projecting malleoli, whereas his original operation was merely a disarticulation.

It must be remembered that Syme's first publication relating to this subject was twenty-two years before his son-in-law, Joseph Lister, first embarked upon his experiments in antiseptic surgery and three years before Morton first used ether at the Massachusetts General Hospital.

Syme listed the advantages of the operation as "first, that the risk of life will be smaller; second, that a more comfortable stump will be afforded; third, that the limb will be more seemly and useful for progressive motion." There was little doubt in Syme's mind of the importance of the first advantage since the common treatment was amputation a hand's breadth below the knee and this was accompanied by a 25 to 50 per cent mortality from infection in the widely opened tissue spaces and medullary cavities of the tibia and fibula (Godlee, 1924).

The risk of surgery has been greatly reduced by antiseptic surgery and later by aseptic surgery and further reduced by bacteriostatic and antiobiotic agents. Therefore, today the first and foremost advantage listed by Syme, namely, "that the risk of life will be smaller," can no longer be listed as one of the main advantages of the Syme amputation. It still remains the most useful of all amputations of the leg because "a more comfortable stump will be afforded" and "the limb will be more seemly and useful for progressive motion." Credit must be given to Syme for bringing to our attention the value of end-bearing in the lower extremity, even though in the era in which he worked, the merit of end-bearing was secondary to the importance of saving of life.

There has been marked difference of opinion about the merits of the Syme amputation. In Canada it has been highly regarded and thought to be the best of all amputations of the lower extremity above the foot and has been used with consistent success since before the first World War to the present day. In the United States there has been renewed interest in the Syme amputation since the International Conference on Amputations held in Ottawa and Toronto in March of 1944, and several writers have expressed their satisfaction with this amputation in publications since that time. The Syme amputation is not performed in the Amputation Center in Nijmegen in the Netherlands. In England the amputation has been condemned by a group of experienced surgeons. In 1954 Mr. J. H. Shelswell gave an account of the current opinion regarding the Syme amputation [12]. He had reviewed the Syme's amputees from the material available at Roehamton; of 534 cases, the 302 patients that underwent the Syme operation before 1939 were chosen for assessment, and a follow-up on sixty-six of these patients was done. Two-thirds had had no significant trouble; 23 per cent, including immediate failures, needed reamputation, and as Mr. Leon Gillis pointed out in discussion this is no higher than follows the standard below-knee amputation. The conclusion of this study was that a Syme's ampu-

tation properly performed was an excellent and long-lasting operation. Mr. W. W. Rentoul in 1954 stated at a meeting at Buxton that opinion was mixed as to the value of the Syme amputation. He believed it was the operation of choice when it was possible to perform it and went so far as to say that he considered it "a crime against the patient to perform a below-knee amputation in such case." He believed that the Ministry of Pensions was largely responsible for the impression that it is an antiquated operation, the reason being that their limb manufacturers could not make a satisfactory Syme's prosthesis.

Harding and Langdale-Kelham in 1957 believed that the Syme operation had met with disfavor after the first World War for a number of reasons which were summarized as follows: Many patients never reached the stage of limb-fitting and may have been subjected to operation under unfavorable conditions. Many underwent reamputation within five years of the end of the war and many failed to tolerate full end-bearing which contributed to the failure of many of these stumps, as did the introduction of the modified Syme's amputation with division of the bone at a higher level. In 1929, however, limbs were provided to allow for partial or full tibial bearing, and these have been used ever since and reamputations after the Syme operation are now uncommon.

Such striking differences of opinion must be due to the same difference in indications for the operation and or some difference in technic of the operation. Alldredge, Thompson, Harris, Gallie, Wilson Irwin, Spittler and others have outlined indications for the Syme amputation:

There should be no infection present. Many stumps broke down or were otherwise unsatisfactory because surgery was performed in the presence of or too soon after infection. Even the severest critics of the Syme amputation have admitted that these factors have largely been responsible for the failures and unsatisfactory results in the past. Spittler [*15*] has employed the two stage operation, first described by Hulnick [*8*] with success in patients with open wounds with active drainage. Bacteriologically suited antibiotics were used.

Syme's amputation is indicated in all destructive lesions of the foot provided an inch of skin of the heel is left that has sensation and blood supply. If injury to the leg has occurred causing decreased circulation, a lumbar sympathectomy may be indicated before amputation.

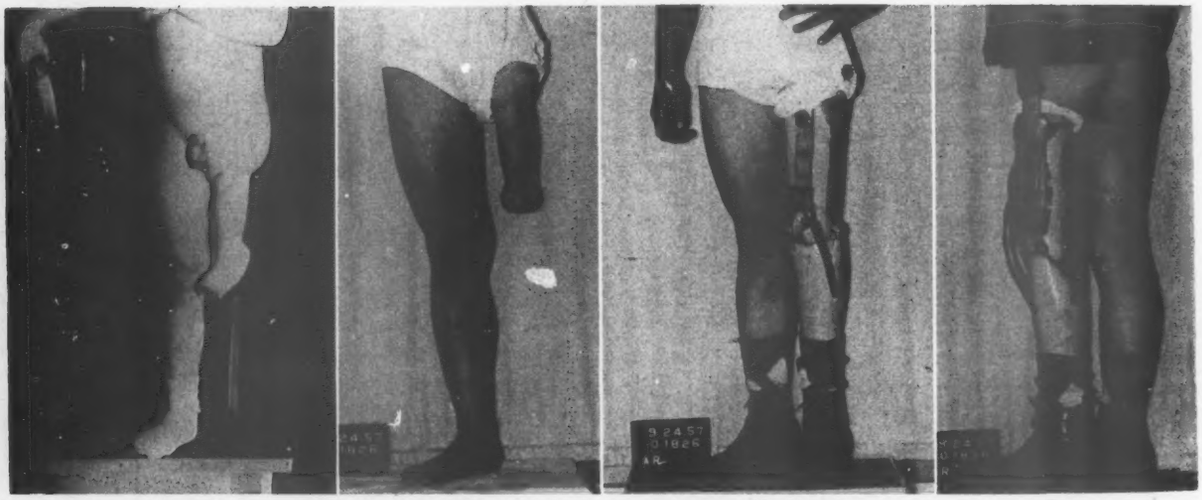
Intractable infections of the bones and joints of the foot is less often an indication for Syme's amputation at present than formerly due to antibiotics.

Congenital deformities of the foot or deformity of the lower extremity resulting in considerable shortening of the lower extremity, as will be illustrated in the cases to be presented, are indications for the Syme amputation.

In selected cases of obliterative vascular disease, Syme's amputation may be indicated. Favorable response to lumbar sympathetic blocks and to lumbar sympathectomy should be obtained first. Harris [*7*] reports 50 per cent successful results in this group. Frostbite and immersion foot present similar problems, but less difficult and such cases are well treated by Syme's amputation.

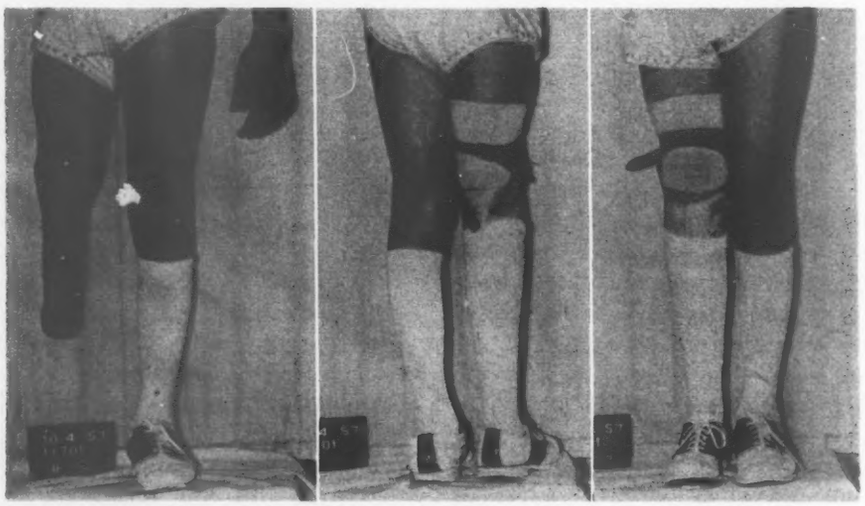
The advantages of the Syme amputation have been reiterated by many writers and are as follows: (1) This amputation permits full weight bearing on the end of the stump. This advantage is retained as long as the patient lives. (2) It is more conservative than the below-knee amputation, leaving the patient a stump nearly as long as a normal leg, therefore, functioning as a normal foot. The patient with a Syme amputation reveals a gait pattern which is almost indistinguishable from the normal. The chief point of variance lies in the swing phase where the hip is flexed slightly more than in the normal to allow clearance of the foot which lacks active dorsiflexion [*13*]. (3) The patient can stand and walk upon it without limitations and can undertake the heaviest kind of work which only a few below-knee amputees can do without damaging the stump. (4) As stated by Elmslie, "If one has a foot (or a Syme's stump) with reasonable skin sensation and capable of bearing weight relatively painlessly, it is possible to escape alive at night from a burning house, for there is no delay in order to apply an artificial limb." There are, of course, other reasons for wanting to leave one's bed at night, particularly with increasing age.

Disadvantages of Syme's amputation are few: (1) It gives a bulbous-ended stump which is unsightly. For this reason, one should perform this amputation on a woman only if she



1A 1B 1C 1D

FIG. 1. CASE I. A, age three years; B, age six years; C and D, age eight years, with full end-bearing prosthesis.



2A 2B 2C

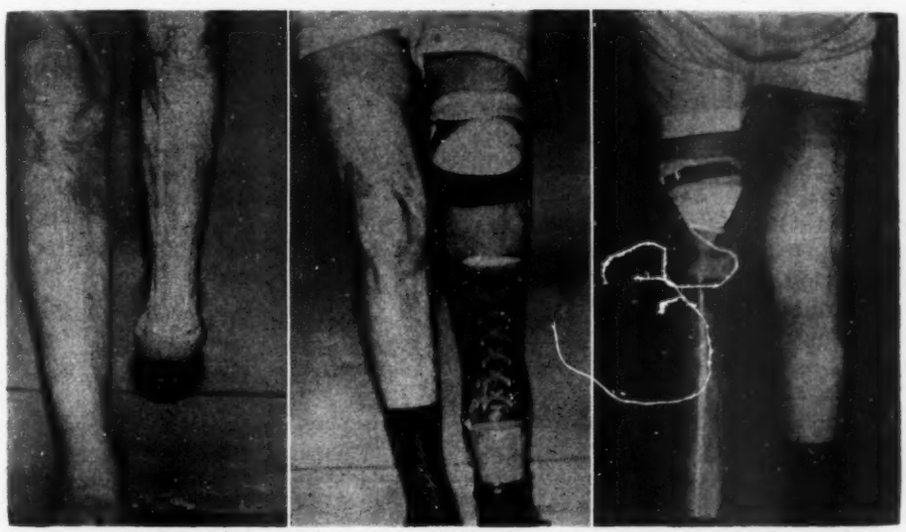
FIG. 2. CASE II. Age seven years. A, three years following Syme's amputation; B and C, with full end-bearing prosthesis.

3A 3B

FIG. 3. CASE III. A, age two years; B, age three years, with prosthesis used similar to that in Case II.

is emotionally stable. The Elmslie modification of the Syme technic (division of the tibia ¾ inch above the articular surface) is probably more desirable for women since the bulbous end is smaller. The improvement in design of a plastic prosthesis also decreases the bulky appearance of the ankle. (2) The Syme amputation requires greater skill on the part of the surgeon in the proper selection of cases, the operative technic and the postoperative care than any other amputation.

Technic of the Syme amputation is well outlined by Harris, Alldredge and others. However, I would like to draw your attention to the



4A 4B 4C

FIG. 4. CASE IV. A, age forty-eight years; B and C, age fifty-one years, with full end-bearing prosthesis.

more common imperfections and means of avoiding them [*21*].

The heel flap must be placed beneath the tibia in such a manner that the plantar surface of the flap is exactly beneath the center of the cut lower end of the tibia and it must be maintained there until sound healing has occurred. This requires painstaking care because the heel flap is a large cup which fits loosely over the lower end of the tibia. At the end of the operation the correct position can best be secured by adhesive strips. Frequent inspection of the stump is necessary during the first two weeks following surgery. If the heel flap is not properly placed, the prosthesis is likely to be uncomfortable.

The tibia must be paralleled to the ground both in the anteroposterior and transverse plane. This does not necessarily mean at right angles to the long axis of the shaft of the tibia. The tibia should be cut through its largest cross section area to insure the greatest possible area for support of the heel flap.

The heel flap should be firm and well attached to the lower end of the tibia. The loose, unstable heel flap can be prevented by subperiosteal dissection of the heel flap. This causes firmer attachment to the end of the tibia. Subperiosteal dissection of the heel flap also preserves the specialized elastic adipose tissue, thereby producing a more comfortable and durable end-bearing structure.

Marginal necrosis of the heel flap is nearly always due to faulty technic. The resulting lateral projections of skin forming "dog ears" are never trimmed, as this might devitalize the flap. Should marginal necrosis occur, the stump is not necessarily ruined unless the loss of tissue is great.

CASE REPORTS

CASE I. A Caucasian male was first seen at the age of three years. A fusion of the proximal and distal ends of the left femur was performed at the age of five and he wore an ischial weight-bearing brace until the age of six when a Syme amputation was performed on the left. He has successfully worn a weight-bearing prosthesis for the past two years. (Fig. 1.)

CASE II. A Caucasian girl was seen at the age of one. She presented a deformed valgus foot due to partial absence of the fibula and the right lower extremity was 1¾ inches shorter than the left. She wore a built-up shoe and three years later underwent a lateral release operation on the right foot. At the age of four years a wedge osteotomy of the right tibia was performed and six months later she underwent a Syme amputation. The right lower extremity was 3 inches shorter than the left at the time of the Syme amputation. She has successfully worn an end-bearing prosthesis with a knee strap for three years now. (Fig. 2.)

CASE III. A Caucasian male was first seen when he was one year old, with two deformed feet. There was very little bony structure in the left foot and it was rotated 180 degrees at the ankle. A

Syme amputation was performed on the left foot at two years of age. He has successfully worn an end-bearing prosthesis for over a year now. (Fig. 3.)

CASE IV. A Caucasian man was first seen at the age of forty-eight and gave a history of an infection of the left lower leg and knee following a fracture in that region at six years of age. After his growing years, he had a residual 4 inch shortening of the left leg. He had an intertrochanteric fracture of the left femur at the age of forty-three with non-union which resulted in an additional 1 inch shortening, making a total of 5 inches of shortening. He was having considerable pain in the forefoot as the foot was stiff in complete plantar flexion. He had a bone grafting and internal fixation of the intertrochanteric fracture and a Syme amputation at the left ankle. He has successfully worn an end-bearing prosthesis for three years following his amputation. (Fig. 4.)

SUMMARY

In the majority of cases that have failed following the Syme amputation, the operation was not indicated, or they were performed under adverse conditions or the details of the operative technic were not strictly adhered to. Further, a percentage of others would have been successful if a good prosthesis had been provided.

Four cases are presented in which prostheses were required varying widely from the standard types used for Syme amputation stumps.

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DISCUSSION OF PAPERS BY DRS. GLOVER; CONNELL AND ROUSSELOT; AND LAMB

JAMES K. STACK (Chicago, Ill.): I simply want to thank Dr. Lamb for bringing up the final subject. Some of the criticism of the Syme amputation you see from time to time is that the skin covering does not hold up. One of my favorite people is an old gentleman from Alabama, who looks and acts exactly like Uncle Remus, who came to our service at the County Hospital in the late 1940's with a worn-out hip. He is the first of the adjuvant prostheses that I had anything to do with. On the same side, he had a Syme-like amputation that was performed way down South about forty years ago. He had a painless, heavy, hard callous, present over the end.

If you ask the average student, at least our students, about these names, Lisfranc Chopart, Pirogoff and Syme, most of them will think you are referring to a law firm on South Street instead of a group of procedures that have come down to us through the ages. This one has really held up, and I think it is a fine procedure.

ROBERT H. KENNEDY (New York, N. Y.): My experience with the Syme amputation has been

in traumatic cases only. During the late war, I had an opportunity to see the patients at three Army amputation centers over a long period.

It was obvious that the Syme amputations were usually left to one man in each of these places, and improvement in the results had grown with their experience. I feel that this is an important point when it is an amputation which is criticized oftentimes by so many people. It is an operation that requires considerable experience to obtain just what you want. I would wonder if it was not worth while to refer all these patients to a few institutions in order to take advantage of those men who had the opportunity (there weren't more than six or eight of them at the most) to perform a number of Syme's amputations; I mean performing seventy-five or one hundred. They changed the details considerably. Often these refinements are written with difficulty, and it would be wise for the experienced men to train just a few men who might have frequent opportunity to undertake the procedure. One should not gain his experience in an occasional case when the object is to fit a man to return to industry.

HAROLD W. WOUGHTER (Flint, Mich.): I have a kindly spot in my heart for the Salt Lake City region, having spent four years in Brigham City in charge of the amputation center, in which we performed about 3,500 amputations, including Syme's amputations. I heartily endorse the indications that Dr. Lamb presented, and also the finer points in the technic he mentioned.

One of the indications for amputation, of course, is when the prosthetic device is superior to the deformity in function and appearance. He showed that very nicely in his third illustration. We have performed bilateral Syme amputations on a couple of fully grown women who were only about 4 feet high, and the deformity was below the knees. They were previously very reluctant to appear socially.

Following the amputations and fitting of prostheses, they promptly got married and returned to social life. There was a great advantage in that they could fall in love with anybody, because they could regulate their height by the length of their legs.

Occasions where there is a bilateral amputation in which a Syme amputation can be performed on one side when there is a mid-thigh amputation on the other has a distinct advantage in walking control. We had a few bilateral Syme's amputations. I am not sure what happened to all of them, although I did try to follow up these patients for a period of about eight years. One had to be reamputated below the knee because of unnatural abuse to the amputation stump, due to alcoholism.

The Syme operation is sometimes superior when there is compromising injury proximal to the foot, and ideal when below-the-knee amputation cannot be well done or a femoral end-bearing type of amputation is not feasible.

CHARLES G. JOHNSTON (Detroit, Mich.): I wanted to ask Dr. Kennedy if it does not raise an issue if you make such an assignment. I remember when I was a student, having an orthopedic surgeon show me a wrench used for a clubfoot. He said, "That should never be used by anybody who has not used it before."

T. CAMPBELL THOMPSON (New York, N. Y.): I rise for just a moment to disagree with Dr. Kennedy. I think this operation can be performed by any good surgeon, with care.

I do want to thank the essayists for preparing these papers on very young children, because I have not had the nerve to do this in those very young, congenital abnormalities. A B.C. amputation performed in a young child for trauma or anything else is apt to give trouble, it does not grow well, the bone comes through the skin, it is small and difficult to fit. We do know congenital amputees have very little trouble, and even those with deformed feet are able to walk on them. I have performed Syme's amputations on a number of these patients, but I have always waited until they were sixteen years old. The operation is fine and excellent then and I feel it will last the rest of their lives.

I am a little worried about those performed at the age of two, three, four, five and older, for fear they may have trouble, that the stump will not stand up and have the pad in the right place.

I hope he will report if he has trouble. I have seen a few performed elsewhere who have had trouble, but I have never done any myself.

ALFRED WELLS FARMER (Toronto, Canada): Dr. Thompson, in discussion, brought up the problem of infants and children. The essayists showed pictures of a small child with a prosthetic appliance. We have now a number of cases at the Hospital for Sick Children in Toronto with so-called modified Syme's amputation, performed under two years of age. These cases are chiefly of absent fibula, with leg length disparity which is going to be of such an extent that leg lengthening procedures or shortening procedures will not be feasible. These infants walk very well with their prosthetic appliances, and one would have difficulties, if the legs were covered, in picking them out from normal children by their gaits.

ROBERT H. LAMB (closing): I would like to say to Dr. Walter, who was at Brigham City Hospital, that I am still seeing some of his Syme amputations since I am with the Veterans Administration Clinic for the Intermountain Area. They are holding up well. We do not have anybody on that service in the area who is having any trouble with the Syme's amputation stumps.

To Dr. Thompson, we took extreme care in these younger children in performing the Syme amputation. First of all, we just removed their malleoli, shaved the surface of the distal end of the tibia and tried to do as little damage to the epiphysis as possible.

The patient presented as Case IV was wearing a 5-inch lift under his shoe and was an alcoholic at the time that I performed the Syme amputation. I cannot take credit for his progress after that, but he has become quite an active member of Alcoholics Anonymous and is holding a responsible job in the Tax Assessor's Office in the State Capitol Building.

Unethical Medical and Legal Practices in Personal Injury Litigation

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IN my surgical practice I am concerned chiefly with patients who are not involved in any legal procedures connected with their disease. The remainder are patients who are referred to me for consultation or treatment after accidental injuries. I am not retained on a salary by any industrial company nor am I what is generally considered an industrial physician. These statements, by way of introduction, are to emphasize that my practice is similar to that of the average general surgeon.

I have been concerned about that portion of my practice relating to accidental injuries since it became evident that certain of such injured patients were being directed by attorneys to other physicians and surgeons before I had completed treatment. Because of this concern I undertook to investigate the background of the legal and medical practices which involve the accidentally injured. I propose to show that segments of the legal and medical professions, in collusion, are engaged in unethical practices to lure the accidentally injured by promises of large monetary rewards, practices which are harmful to both professions and which are contrary to the best interests of employers, employees and the general public. I further propose to make specific recommendations to remedy these practices.

The Facts. Solicitation: Let us first consider the problem of solicitation or "ambulance chasing" of personal injury cases and its ultimate effect upon good medical procedure and the welfare of the patient. The patient may be approached by persons who advise him that he can capitalize on his injury only if he has a good lawyer. These people represent attorneys competing for the right to legally represent the patient. "Chasers" try to outdo each other in representing what their attorney will do for the prospective client. Exaggerated claims are made and previously successful cases, wherein large settlements were achieved, are discussed. Photostatic copies of settlement drafts may be used to illustrate.

Solicitors often see the patient immediately after injury or while he is still hospitalized. Early or late the patient becomes convinced by one of the chasers and signs a contract with the law firm offering the "best results." Ambulance chasing may be conducted by attorneys in person but it is usually through runners or touts. This last group may include labor union officials, officially or unofficially; former clients; fellow employees within the specific company or industry; hospital attaches; policemen; or professional chasers with a variety of backgrounds. Doctors themselves sometimes become involved in soliciting legal cases among their patients for their lawyer friends—perhaps only for the purpose of protecting a medical fee.

Solicitation of personal injury claims is found in all fields of personal injury law: Railroad, Workmen's Compensation, Admiralty and General Torts.

Let us take, as an example, the situation in the railroad field where the big money is involved. Financial success of unethical law firms in this field has inspired activity in other fields. The 1939 amendments to the Federal Employers' Liability Act [1] coupled with a "liberal" interpretation of that act by the Supreme Court of the United States has converted, for practical purposes, what was originally a common law action grounded on negligence, to a compensation act. The amount of the award is not determined by any statutory standard, but by the ingenuity and histrionics of plaintiff's counsel, and the vagaries of a jury of laymen [2]. This has opened a fertile field for astute lawyers and resulted in some astronomical verdicts.

Plaintiffs claim that they win 95 per cent of employee injury cases against railroads in the courts of original jurisdiction. This high percentage of wins plus large verdicts make railroad employee cases attractive to plaintiffs' attorneys working on a contingent fee basis of from 25 per cent to 50 per cent. This attractiveness has brought about competition between law firms and resulted in the widespread solicitation of potential clients, our patients, for the privilege of representing them legally.

Ambulance chasing is prohibited not only by the canons of ethics of all local and state bar associations as well as by the canons of the American Bar Association, but also by specific laws in thirty-three states [3].

This practice does not stop with competition and solicitation but rather breeds violation of additional ethical canons. For example, while awaiting settlement or trial, law firms may give financial support to the plaintiff and his family in monthly amounts of between $100.00 and $300.00, and these amounts are charged against the final settlement figure. The outright purchase of cases by "gifts," such as a new car or the reduction or elimination of a home mortgage, has occurred. It is common for the attorney to advance the costs of court, investigation, medical examination, hospitalization, and medical appliances such as back braces and the like. On occasion, law firms have guaranteed a specific net recovery to the potential client, such figure matching the offer made by other attorneys or the employer, and usually with the agreement that the law firm will receive 50 per cent of the settlement or verdict in excess of the guarantee. Needless to say, the chasers indulge in self-advertising or self-laudation and successful firms may attempt to convert their clients into tipsters or chasers, thus broadening the "sales organization." Such arrangements require the law firm to be in a position to make sizable capital investments and in so doing they establish a financial interest in their cases, also in violation of the legal canons of ethics.

In the field of Workmen's Compensation, the individual State Acts generally provide specific payments for specific injuries and/or temporary total disability. The dollar value in these cases is much less than under the Federal Employers' Liability Act. Solicitation exists here, too, but almost exclusively by either official or unofficial arrangements between labor union officers and the attorney involved. To be financially successful in this field, a volume business is required. I have in my office a letter from a law firm, addressed to an individual, soliciting his Workmen's Compensation case and advising him that a review of his file indicates a possibility of obtaining additional compensation. The potential client, a patient of mine, had never heard of the law firm prior to receipt of the letter. This type of solicitation appears to be a flagrant violation of the rules. Some employers or insurance companies have had to change company doctors because study revealed that a great number of cases being treated by a specific company doctor terminated in the hands of plaintiff's counsel. The results of the change supported their viewpoint.

In the general tort field a jury determines the amount of the award. Therefore there is considerably more chance of obtaining a greater dollar rate per case than exists under Workmen's Compensation. In this field we find cases based upon food poisoning; fall-downs; transportation accidents involving automobiles, trains, planes and buses; malpractice actions involving physicians, dentists, druggists, hospitals and beauty shops; as well as many others.

It is in the general tort field, particularly, that we find a variety of tipsters, including hospital employees, policemen, and professional solicitors like the one who has his car equipped with a radio tuned to police frequencies and makes it a practice to arrive at the scene of the accident ahead of the officers. When there he obtains photographs, names of witnesses, and other information of value which he sells to the plaintiff's attorney making the highest bid. This places the attorney in an advantageous position to secure the right to represent the injured.

I have set forth in brief some of the practices of the "soliciting" law firms in the personal injury field because it is imperative that we become cognizant of the background and realize that this is big business.

A recent article which appeared in the *Saturday Evening Post* [4] concerning ambulance chasing has as its main character a true to life chaser who has a reported income of $30,000.00 to $50,000.00 a year. He is merely a "layman" chaser.

Astute business men insure their sizable investments whenever possible, but this proce-

dure is not available to the unethical attorney. Therefore, his "insurance" comes from the other important member of the team, the unethical plaintiff's physician. Through exaggerated opinions, expressed in written reports or testimony, he attempts to make certain the jury will bring in "the more adequate award" as referred to in the book, "Modern Trials" [5] by Melvin Belli, past President of NACCA and well known for his work in the field of medical malpractice. The more adequate award can be defined as an amount of money adequate to compensate the client for his legitimate injuries. The "more" is a plus feature which takes care of the guaranteed net recovery to the client; fees for runners; prepaid medical costs including examinations, hospitalization and appliances; costs of court and investigation; repayment of advanced maintenance costs; "legitimate profit" for the attorney; and a reserve for "future investments."

Affiliation of Unethical Physician with Unethical Attorney. Once a physician or surgeon has associated himself with an unethical attorney, he is obligated as a member of the medical-legal team. A "just" evaluation of the injured client is not necessarily required and it is sometimes preferred that medical opinion be modified or exaggerated to insure the more adequate award.

The patient may be told that his original doctor was "for the company" and that this doctor's main interest was to get the patient back to work; such procedure, it is implied, would have been to the patient's disadvantage.

It is suggested by the attorney that his new doctor is an expert in the particular case involved. He is said to be very thorough in his examination and sound in his advice. Strangely enough, based upon this doctor's expert testimony, he apparently is an expert in all types of cases. His testimony, at least, has covered many fields. This so-called expert will impress the patient with his thoroughness of examination, particularly with details concerning history of the accident and his suggestions as to how the accident may have occurred. He will help the patient bring out points not previously emphasized sufficiently or possibly even thought of.

The physical examination by the plaintiff's doctor may be extremely thorough. The report is always very thorough, and the doctor will list every detail which conceivably, although remotely, might be associated with the injury. This includes every congenital anomaly possibly aggravated by the accident. Each becomes a talking point when discussing the case for settlement with the employer or in illustrating it medically to the jury. The plaintiff's doctor may order a back brace, cane, crutches or some other device for support. He may reapply a recently removed cast or find it necessary to admit the patient to a hospital for traction or physiotherapy. To the patient this procedure suggests that the previous treatment was insufficient and the original doctor neglectful of his interests.

The report to the attorney is usually long and sad. Suture lines become fractures. Old fractures, long since healed, are set forth as "evidence of fracture." A single traumatic incident as the originator of extensive arthritis or cancer may be suggested. The report usually ends with a bleak prognosis, such as contained in the following excerpts taken from a letter representing an actual case:

"*Diagnoses.* (1) Dislocating facet joint between the 4th and 5th lumbar vertebrae on the right side. (2) Possible ruptured intervertebral disc between the 5th lumbar vertebra and the 1st sacral segment; also facet joint pathology between the 5th lumbar vertebra and the 1st sacral segment.

"*Comment.* This patient is in need of an operation for exploration of the intervertebral disc between the 4th and 5th lumbar vertebrae and between the 5th lumbar vertebra and the 1st sacral segment, following which he should have a fusion to include the 4th and 5th lumbar vertebrae to the 1st and 2nd sacral segments. Unless he has some operation similar to this it would be my opinion that he is totally and permanently incapable of carrying on the work of a railroad brakeman."

Strangely enough, following settlement of the case for $17,500, and without the recommended surgical procedure, this man presented himself to his employer as able for duty. He later returned to his original job in spite of his permanent total disability.

Another letter from an attorney to his client included these statements:

"As you will recall, Dr. _____ made a very thorough examination and took a great number of x-rays, and from his study he is of the opinion that you are suffering from: (1) osteoarthritis of the cervical, dorsal and lumbar

spines; (2) from the history—probable brain concussion; (3) possible disc rupture between the 4th and 5th cervical vertebrae with complete loss of the cervical lordosis; (4) facet joint syndrome; and (5) scoliosis of the dorsal and lumbar spines."

This patient would become ill regardless of his previous injury or present condition. Yes, the closing paragraphs of the plaintiff's doctor's report usually bring into play such phrases as "totally and permanently disabled"; or "the patient has a condition for which there is no known cure at this time"; or some other bleak prognostication. Never will you see a report which reads "there is little or nothing wrong with this patient and he should return to work."

Reference is made to three cases from the files of one physician known to be frequently associated with the same questionable attorney. Postsettlement investigations proved that he was either continuously fooled by his patient's story, was incompetent, or purposely exaggerated his opinion.

In each case it was the examiner's opinion that the patient was unfit to perform the arduous duties of his employment following the alleged injury. One patient was an "ash pit" man, one a railroad yard conductor, and the other a railroad brakeman. In each instance secret movies were taken of these patients doing heavy labor at other jobs while they were said to be disabled. The movies were shown to the Ethical Relations Committee of a Medical Society while its members listened to a reading of the doctor's opinions on each of the cases. The physician involved was suspended from the Society for a period of six months. It is believed that his value as a "court expert" is terminated.

In some situations physicians have given financial as well as medical aid to attorneys by allowing a sizable account to grow wherein the attorney may owe the doctor several thousand dollars in fees for testimony, examinations and reports. This is conducive to additional unethical activity such as the reference of cases to the attorney and the inclination to remain on his good side by rendering favorable opinions. We have all heard, too, of doctors treating cases on a contingent basis.

Result of Personal Injury Claims Racket. What is the effect of this personal injury claims racket on the medical profession, the patient, the employer and the public?

To begin with, the prestige of the medical profession is lowered in the eyes of the public and ethical attorneys. The honest physician is fast losing respect for his unethical colleagues. Conversely the public may feel that because a doctor testifies considerably in court that he is extremely well qualified with respect to medical and surgical ability. The ethical physician suffers by damage to the doctor-patient relationship that he has established before the medical-legal team takes over. There is also the damage to his reputation by hearsay from the injured patient's friends and acquaintances who know that he changed doctors.

The patient may actually develop permanent or partial disability as a result of emotional disturbances produced by medical opinions, testimony or reports purposefully exaggerated; or he may sustain a general moral breakdown if he is basically honest. Where the patient has been advised to delay the use of prosthetic appliances, discontinue beneficial treatment, or return to discarded supportive devices, he may actually suffer physical as well as mental setbacks. When rehabilitory efforts are finally made, it may be too late to get the greatest possible function of the part. In fact, it may be impossible to get any function. There are case records wherein the rehabilitation of an amputation stump has been delayed by legal advice until after settlement. We know what the lapse of two or three years can do to an untreated limb with respect to the possibility of the future successful use of prostheses.

Financially, the patient suffers since he may lose his job or have to take a lesser one because of poor treatment and the lack of proper restorative measures. It is even more probable that he will lose income because of a longer period of temporary total disability than required under ordinary circumstances.

How is the employer affected by the personal injury claims racket? First he suffers from the loss of trained personnel, temporarily or permanently. He may be without his trained employees longer than necessary. Temporarily he must replace the disabled employee. Also he is forced to pay excessive settlements due to the "built-up" medical diagnosis and its bleak prognosis, or because of actual bona fide permanent conditions which would not have resulted had the medical care been adequate rather than forensic. Even as the doctor-patient relationship suffers, so does the em-

ployee-employer relationship as the result of either official or unofficial labor union activity in the field of solicitation and advice invariably given the injured brother or member that "dealing direct with the company will not pay off."

Financially, this racket affects the public, and indirectly the individual citizen by reason of increased taxes to support excessive court dockets. Excessive verdicts resulting from procedures set up by the unethical medical-legal teams are, whenever possible, passed on to the public in the form of increased costs of insurance, transportation, and in products manufactured.

Citizens with legitimate injuries and legitimate claims suffer because justice may be defeated by the "long wait" for trial. Public faith in the legal and medical professions is lost because of moral decay fostered by this small group of unethical practitioners.

As Morton M. Hunt stated in his paper, "Damage Suits: A Primrose Path to Immorality" [6], "The lawsuit for personal injuries has become a national pastime—Americans are suing other Americans, business concerns and governmental bodies for larger sums and for a wider variety of complaints than ever before—and collecting more than ever before."

Certain members of the Plaintiff's Bar have organized the National Association of Claimants' Compensation Attorneys known more briefly as NACCA. This organization is set up to educate plaintiffs' attorneys in the science of representing the personal injury client so as to obtain the greatest dollar value possible from the case. State and national conventions are held where nationally known speakers from the medical, legal and political fields discuss the latest theories of law and medicine in all of their ramifications and what is being done politically, through legislation, to "better" the picture for plaintiffs in general. Some very well known members of this organization as well as those without the organization feel that the Canons of Professional Ethics of the American Bar should be re-evaluated in the light of modern day practices and changed to permit the practices described.

Doctors are being advised by this group along the lines set forth by Attorney DeParcq [7] of Minneapolis in his address before the National Meeting in 1953. He said " . . . Where two views of the future of the patient are permissible—the optimistic view and the pessimistic view—and there are reasons that can be advanced in support of either view, then the doctor in a lawsuit is fully justified in resolving the doubts in favor of his own patient and taking the pessimistic view. . . . It is his duty to aid and assist the lawyer in rehabilitating the patient financially as well as physically and . . . his duty does not end merely when he prescribes care and treatment." Some further insight may be gained in reviewing this additional quotation from Mr. DeParcq's talk before the National Association of Claimants' Compensation Attorneys, " . . . If you are an unethical lawyer, this conference will give you an opportunity to tell the doctor to forget about the existence of his office records; but if you are an ethical lawyer, you can at least suggest to him that he is under no duty or obligation to bring them to court. He can prepare a few notes with nothing but dates and facts to refresh his recollection, leaving the office records in the left lower drawer of your desk, in the one case; or in the left lower drawer of the doctor's desk, until specifically requested. I might add, parenthetically, that I was not requested to make a speech on legal ethics here today."

The *NACCA Law Journal*, published semi-annually, is admittedly slanted for the plaintiff. Circulated free to judges and law schools for their edification, it is increasingly cited in judicial opinions. It contains a section wherein reported and non-reported personal injury cases are cited involving a verdict of $50,000.00 or more. One national industrial organization has conducted an investigation of all such cases cited in the *NACCA Law Journal* affecting that particular industry and has determined that a number are entirely misleading and/or inaccurate.

NACCA makes every effort to place its members in state and federal legislatures where they work to have themselves assigned to committees wherein they can do the most good for the national organization. Here they are attempting to legislate on behalf of the plaintiff and disenfranchise defendants.

It is obvious that the pursuit and management of personal injury claims has evolved beyond the ethical practice of law and has been transformed into a big business. In an attempt to justify his acts, the soliciting attorney has revised the legal code of ethics in practice if not in theory. Such lawyers say that since

everyone solicits business, the canons of ethics should be scrapped or modified to permit this practice. They point out that defense law firms wine and dine industrial and insurance clients. They regard this as solicitation of business not different from that conducted by the chaser at the door or bedside of the accident victim. It is also claimed that the "poor but honest" claimant has been forgotten by the law because he cannot afford to obtain justice by waiting the required time limit. He is therefore forced by economic circumstances to make a quick and cheap settlement.

It should be emphasized that attorneys and doctors referred to in this article are in a small minority. When a patient has been injured under circumstances where someone else is, or may be, legally responsible for the consequences of his injury, that patient may well need the services of a good and honest lawyer just as he needs the services of a good and honest doctor.

Recommendations. I commend the American Bar Association in its effort to once again restore legal ethics within the law. Its committee on solicitation has completed an extensive study of this subject and has made recommendations to strengthen the canons of ethics particularly involved.

All bar associations should continue along present lines giving consideration to individual disbarment proceedings. Efforts to enjoin unethical attorneys from continuing in the practices set forth herein are to be encouraged. Private agreements can be made wherein unethical attorneys agree to refrain from their former practices while at the same time they confess to them.

There should be no desire on the part of any association to wreck the practice of a professional man. Its only interest should be in seeing that his future professional activities are conducted in accordance with his oath of office or position. Duly authorized committees from bar associations should continue to work in conjunction with medical societies on a comparable level in an effort to outline and understand their mutual problems. Particular emphasis should be placed on stamping out the vicious practices of which I complain. On a state level, statutes supporting the canons of ethics should be enacted to make it easier for the interested professions to take punitive action against the malpractitioners within their ranks.

By the best means available, the public should be advised as to the activity of the organized bars and the medical profession with respect to their efforts to put out of business the shyster and ambulance chaser.

I strongly advise that the medical profession take a more realistic view of the part played by some of the men embracing the title of physician and surgeon. Organized medicine must recognize that this racket cannot continue without the medical charlatan as an accomplice. Although these misfits be relatively small in numbers, the noise and commotion raised by them is great.

Organized medicine must continue to explore and experiment with various plans which have been designed to correct the shortcomings and abuses which are presently all too common in judicial proceedings concerned with medical proof. Such experiments as "Impartial Medical Testimony," [*8*] set up by the special committee of the Association of the Bar of the City of New York, should be encouraged. The Maryland [*9*], Utah [*10*] and Minnesota Plans [*11*] should be subjected to further experimentation until the American Medical Association and other associations, such as this one convening here today, can recommend to the courts a system which will provide ethical and honest medical opinions.

My remarks should not be interpreted as a recommendation for any one plan especially if such plan would deprive any citizen of the right to summon witnesses in his behalf. Therefore it is again earnestly recommended that organized medicine give consideration to the problems and assign committees the duty of further exploration.

Unfortunately, today it appears that certain physicians have become categorized as either plaintiff's doctors or defendant's doctors. In an ideal situation we will see a doctor accept an injury case only if he is qualified to handle it, treat it to the best of his ability, and honestly advise the patient and his attorneys as to his opinions whether or not these opinions favor the legal case of the patient. He will give the same information to the defense when so authorized; consult with doctors previously handling the case for any valuable information they may pass on that has a bearing on the diagnosis or treatment; and repeat in court, if necessary, the same honest opinions maintained previously. This physician would have no inter-

est in the case other than bringing about recovery as soon as possible and getting paid a fair amount for his services. In short there would be no "plaintiff's opinion" or "defendant's opinion"; there would only be impartial opinion.

To stop unethical physicians who associate with questionable attorneys, and make testifying in personal injury cases a lucrative business by giving distorted opinions, punitive action must be taken.

Dr. Harrison L. McLaughlin [*12*] stated in a recent address that, "Human nature, a lust for money, the fallibility of human judgment and variations in the competence and wisdom of physicians are here to stay." That, I am afraid, is true. We are not going to change the basic honesty or competency of the medical charlatans by writing papers or delivering speeches. We can, however, bring an end to this problem by promptly and continuously removing them from the medical-legal scene. As punishment for first offenders, it is recommended that the physician be suspended for at least a six months period from his local medical society. This generally means automatic suspension from the membership roles of the State Society and the American Medical Association. For further offenses, more drastic measures should be instituted.

To accomplish ferreting out these offenders, sincere and interested physicians must volunteer their services to sit as members of Ethical Relations Committees, and such committees must understand the problem and be willing to accept available evidence as proof of unethical conduct. Ethical Relations Committees will have little difficulty when complaints are brought before them concerning questions of overcharging, padding of bills, or factual matters. However, a great number of the complaints will arise from the opinions, exaggerated or minimized, rendered by the unethical doctor in his reports, depositions or actual court testimony having to do with legal cases.

There will be occasional unjustified complaints based upon an honest difference of opinion between the plaintiff's and defendant's physicians. Certainly no punitive action should be taken in such instances. Also the committees must realize that it is possible for individual organizations or industrial associations to conduct studies over a period of time wherein many cases are reviewed. If a significant number of questionable cases show unusual coincidence of association of a physician with one or two attorneys, this physician may be suspect of dishonest or unethical practices, or at least called upon for an explanation.

The Ethical Relations Committees should come to an agreement as to some formal type of complaint form that they can recommend be used by those who feel that they have a justified complaint. Further, these committees should encourage complaints from bona fide and sincere doctors, lawyers, individual employers, insurance companies or industries who have become involved with the unethical practitioners of record.

I suggest that formal complaints based upon the questionable honesty of medical opinion contain the following information, preferably by individual sections, specific in nature:

1. A list of cases in which the physician in question has been involved. Each case should be identified by the names and addresses of the plaintiff and defendant, the court file number, or the plaintiff's or defendant's file number, the amount and the date of settlement, and the name of plaintiff's legal counsel. This list would provide the means to show any more than coincidental association of the physician with any one attorney. It could also show whether any of the attorneys represent plaintiffs who live at any great distance from the attorney. In the latter instances it can frequently be assumed that the patient could have found competent legal and medical aid closer to home and that he was solicited by the attorney representing him.

2. A section containing individual case histories, including postsettlement investigations, which tend to prove that the subject doctor was incorrect with respect to his diagnosis or prognosis on a rather consistent basis. In this regard, the committees must accept the obvious inferences and not take the position that because perhaps only twenty cases are contained in this section that the complaint is unjustified in that it did not report on the other 15,000 patients previously treated by that doctor.

3. A section containing the opinions as reported by letter, deposition or court testimony of the subject doctor compared with the opinions of other doctors involved in the case.

4. A section that would contain only the reports, depositions, and trial testimony of the subject doctor, primarily because other opin-

ions are not available. This section would be of value because it would tend to show the consistent bleak prognosis in case after case and the absence of any opinions as to a "rosy future" on the part of the plaintiff.

As an example of a case in this last category, I have in mind an instance involving a doctor in a Midwestern city who enjoys a wide reputation. He wrote a letter to the attorney representing his patient and set forth the following with respect to a postconcussion syndrome, "There is no recognized medical or surgical treatment which could be used in accelerating or initiating improvement from this troublesome group of symptoms. There is no dependable criterion upon which a reasonably accurate prognosis can be based." Within the few months that followed, the case was settled for $25,000 and shortly thereafter the same doctor wrote to the attorney again, in reply to a request, since the patient now wished to return to work for the former employer. This is what he now said: "When I saw Mr. ——— the other day, he appeared to be in excellent spirits. He stated he was 'completely well now' and had no headaches, no pain in the neck, no pain in the arms or shoulders, and no pain in the left hip. I performed a detailed neurological examination upon him and found absolutely no evidence of neurologic abnormality . . . Therefore, my opinion is that there is no neurologic contraindication to his resuming his work as a switchman." The two reports were approximately one year apart. The first report, if read before a jury, would certainly and unjustly convince a group of laymen that there was absolutely nothing that could be done for the poor plaintiff.

The records of the National Railroad Adjustment Board contain many cases involving disputed claims of railroad employees who had sued their employer for severe permanent injuries resulting in total disability, such supported by doctors of the type I am discussing today. Following sizable settlements or verdicts, the employee would attempt to report back to work and upon being denied this privilege by the railroad, which had not yet forgotten that it had paid $50,000 or more because of the "permanent and total disability" features of the injury, would file an action before the Board in an attempt to force the former employer to put him back on the payroll. In many of these cases, the same doctors who had, but a few short weeks or months before, testified as indicated for the plaintiff, reversed themselves, and found the patient was completely recovered and able to resume his former occupation.

CONCLUSION

The foregoing recommendations are not suggested as the only and final answer to the problem. Ethical doctors must regard it as a duty to testify to the knowledge that they have obtained through physician-patient relationships once the patient has voluntarily wavied the legal privilege of preventing such testimony. Obviously, such men should testify honestly and it is important for them to be prepared so that they may conduct themselves well before the jury and cooperate legitimately with the attorney propounding the questions. It is entirely ethical and recommended that doctors, about to appear in court, review the facts of the case with the attorney. Such a procedure will assist both in avoiding embarrassment and possible anger in court, which is basically why many doctors wish to avoid testifying. Ethical lawyers complain bitterly that it is difficult or impossible to get outstanding medical men to testify in court. Local medical societies must take measures to rectify this situation. My remarks are not to be taken as any indication that either defense physicians or defense counsel may not also engage in similar unethical practices and where applicable the stated recommendations should be applied impartially.

I wish to commend the American Medical Association and Mr. C. Joseph Stetler, the Director of the Legal Department thereof, in connection with their recent work in providing educational films on this subject as well as conducting medical-legal symposiums in various geographical areas of the country for the mutual edification of the legal and medical professions.

A serious problem confronts this profession as well as the legal profession. Articles and speeches may only highlight the problem; they will not cure it. We can rehabilitate the professions only by prompt and continuous action supported by honest and ethical men who are willing to stand up and be counted.

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DISCUSSION

Harrison L. McLaughlin (New York, N. Y.): Dr. Brown's essay has very competently outlined a situation, the import of which is increasing as steadily as is the incidence of litigation in relation to accidental injuries. Before the medical profession is justified in casting the blame elsewhere, it should put its own house in order. This will not be done by legislation, for those who presently are prostituting their profession cannot be changed, only punished.

The surgeons of the future remain uncontaminated. A great majority of the patients treated in our clinic are involved in the types of litigation which Dr. Brown has discussed. He may rest assured that, after listening to this report, I will place a little more emphasis on the morals of surgery in my attempts to teach and train the young surgeons who are taking care of these patients and who will soon be entering private practice.

Preston A. Wade (New York, N. Y.): This is a very valuable document for us because we are all interested in the legal side of our cases, since so many of them come to litigation.

Dr. McLaughlin has actually challenged this Society, I think, to take part in the effort to join with the legal profession to do something about it.

I am not sure what that shall be, and I think probably it will be the duty of the Council to take up such an effort.

It may be that this being a national organization something will be done about it, although the punitive legislation must be initiated in each state.

I would like to say just one thing that has always bothered me about the ethics of the legal profession: I have argued with my good, honest, legal friends about this. I say the ethics of the legal profession are somewhat different from the medical, because we base our ethics on the truth alone. We want facts, and nothing else, although the canons of ethics of the legal profession say they want justice and truth. It is difficult for me to say how justice and truth comes out when some very honest adversaries say exactly the opposite thing to one another and do not seem to be a bit upset about it. They judge the standard of a good lawyer by his ability to do something by trick and wit that he really does not deserve to achieve by the facts in the case.

Witness Clarence Darrow was one of the greatest men in criminal law we have ever known. Why was he very good? He was very good because he

saved Loeb and Leopold, who, obviously everybody knows, should have been hung. He saved them so they could go on, one to be killed in an institution, and the other to write a book of rather doubtful value.

I suggest that we consider taking part in this effort. It certainly is a needed reform, and perhaps we should take the lead in it.

RALPH G. CAROTHERS (Cincinnati, Ohio): This horrible situation which Dr. Brown has so ably presented, I can tell you, is a true one. It is principally concerned with the railroad industry, which has not got a Workmen's Compensation type of law. We, as citizens, in a sense, are somewhat responsible for that because we elected officials to Congress who, in their wisdom, pass laws for Beck and Hoffa to gain the positions and power they have obtained.

The lawyers and some doctors are inclined to make gladiators out of the railroad workmen who get injured. The lawyers couldn't do it without the doctors, and that is our problem.

They are, however, pulling some fast ones. In Chicago, there was a case of a railroad employee who lived, and was injured, in Cincinnati. He got on the docket years ahead of perhaps some poor kid in the stockyards district who had been run over. Somebody up there got that case on the docket because this was supposed to be a hardship case. Believe me, he was rich after he got finished.

Some of these doctors have been unfrocked, as it were, and I know of one, at least, who was expelled from the American College of Surgeons, and others who have been censored by the local medical societies. But there are plenty of others ready to join in the fray.

Two things have got to happen to clear up this sorry mess, because I don't think we will ever do away with crooks completely. One thing is that we have got to have a type of Workmen's Compensation law which is based upon the attitude of the Old English Dog Tax law. It doesn't make any difference whose dog kills your sheep, and it doesn't make any difference how gentle your dog is. In one case, you collect, and in the other case, you pay a tax for your dog, even though he never killed a sheep.

These companies must simply get the attitude that the industry must be responsible for injuries which occur in the course of their operations, regardless of what individual is at fault.

Another thing we have got to do, and it can be done—because it was done in the instance of the insanity cases—and that is to get the judiciary to have a panel of doctors to examine these cases before trial. In the case of the claims of insanity, these criminals are examined and it is decided either the prisoner is insane or he is not insane, and the matter is never brought up again in the trial. No matter how rich he is, he cannot pay the psychiatrist to try to get him out of it.

This could be done in the case of these injury cases, the panel of doctors could be appointed by the court; they would examine these people and make a fair appraisal of the amount of injury which the individual had sustained. Then there would be no more of this business in which one doctor says the man is 95 per cent hurt and the other doctor says the man is only 5 per cent hurt.

RICHARD J. BENNETT (Chicago, Ill.): I am intimately associated with both the Workmen's Compensation and Federal Employee Liability Acts.

For those who don't know exactly what this involves, Illinois was recently used as the guinea pig to develop a model Workmen's Compensation Act. Consequently, the records of the Workmen's Compensation Commission were gone into very thoroughly over a number of years past, and all of the ghosts were brought out and aired very freely, with the result that the doctors were found at fault, the lawyers were at fault, the unions were at fault, everyone was at fault. They threw out all the dirty wash and everybody tried to clean their own mess up. I think that we, ourselves, to some extent, must clean up our own profession.

In the Workmen's Compensation work we find that, as Ralph Carothers brought out, the companies minimize the amount of partial permanent disability. Employee's lawyers certify maximum disability with the result that often the Workmen's Compensation Commission takes a figure midway between the two estimates and says: "Well, this is it."

Fortunately, or unfortunately compensation commissions may arbitrarily set a certain figure for a certain fracture or injury, not necessarily taking into account that an excellent result has been obtained.

There is no question but that under the Workmen's Compensation Act of the Federal Employees Liability Act, the person has been injured. If there is no question about disability, I think they are entitled to a reasonable amount for the disability that they have suffered.

What is a reasonable amount? As far as the Federal Employees Liability Act is concerned, the amount is set by the jury and is wide open as to the amount that can be awarded.

I would recommend very strongly that this Association have a medical-legal committee to go in and help out with this very serious problem with which we are faced. I think that if we just come up, as everybody else does, and say: "Oh, well, let George do it—let the other fellow do it," I think we are missing the point. I would like to recommend that we investigate this problem and help.

DONALD GLOVER (Cleveland, Ohio): I think

Dr. Brown is to be commended for bringing up a subject we all know about, but we do not like to talk about. It is a difficult item to discuss before an organization of this kind. But it is one that we all agree has a great importance for us and is of particular importance to our patients.

As chairman of the Mediation Committee of the Academy of Medicine in Cleveland, we have had many instances in which complaints were brought in involving the interposition of an attorney between the patient and the doctor. This is completely wrong. Whether or not it is wrong ethically, I am not sure, but I am sure it is wrong morally.

As Dr. McLaughlin said, this is more a problem of morals than of ethics. Anything which handicaps the patient by legal restriction is not morally sound as far as we are concerned. Everyone in this room occasionally has to give a medico-legal report on a patient. The attorney may think he has a right to privileged communication with the doctor and that the doctor does not need to tell the patient what he thinks. I believe that this is dead wrong, and the lawyers should know it is wrong. I will not accept a patient for examination unless the attorney agrees that the patient will receive a copy of my report. If all of us take a clear position on these principles, the legal profession will very soon find that it is unprofitable for them to try to carry on such questionable practices as have been described. It is a matter of morals between us and our patients, and we can afford to stand up and be counted as insisting that the rights of the patient be respected.

HARRY W. HALE (Buffalo, N. Y.): I, too, would like to commend Dr. Brown on an excellent presentation of a very widespread problem. Every one of us who has any contact with cases of trauma is aware of this problem in its many forms. We are all aware of the distinct effects this type of thing has on the patient's morale, later recovery and on the doctor-patient relationship. Moreover, as we are all included in those who pay for it we should be conscious of the effect of such practices on the cost of settlement of the cases involved.

There certainly is no coincidence between the frequent, repeated association of the same doctor and the same lawyer in case after litigious case. One does not get to smell like a polecat by playing with Siamese kittens. However, in our judicial system association doesn't prove guilt and we have to go beyond that.

Nevertheless, such association should be held up for rigid scrutiny, and any violations of ethics punished. We can help out in this matter in many ways. Several have been mentioned already. But, one of the things we have to keep in mind is that we have to be willing to express our opinions, and willing to appear to testify, whether it be in court as impartial witnesses, or in medical society investigations of such matters. This is something that we, too often, try to evade.

Furthermore, I have a strong feeling that further development of the plans and systems of impartial witness panels already in use in some areas can be greatly expanded and improved to the benefit of all.

OSCAR P. HAMPTON, JR. (St. Louis, Mo.): I certainly enjoyed Dr. Brown's presentation. I would like to discuss two facets of this problem.

Members of the legal profession as well as members of the medical profession can be indicted for the part they play in the unsavory damage suit situation under discussion. I cannot allow the indictments of the medical profession alone to go unchallenged.

Did you ever stop to think that, like in the Western television movies, it is necessary to have some bad guys and some good guys for the present damage suit situation to develop? The good guys (the defendants' lawyers) don't want to stop the bad guys (the ambulance chasers), or they would not have the business of defending the lawsuits. The most upstanding attorney defending damage suits would not have the same volume of business if it were not for ambulance chasers. So, I don't believe they want to stifle it.

Where might this Association play a part? We are interested in the teaching of trauma in medical schools. Perhaps we could play a part in improving or enlarging on the teaching of problems of the forensic medicine. Most of the education in the undergraduate years is in what I call the guessing specialty, internal medicine. Medical students are trained to make a diagnosis regardless. If it can't be made on physical findings or objective findings, then it must be made somehow. Every patient who complains has got something wrong with him, so diagnose it; make it on subjective complaints. That is the excuse given by many members of our profession to justify, as an example, a diagnosis of a ruptured disc in a patient with pain in the back and pain down the back of the legs with no objective findings, no atrophy, no reflex changes, etc.

Perhaps they do these things in some instances because they are trained to make a diagnosis on guessing. They use as an excuse the necessity for making a diagnosis to explain the patient's complaints. Perhaps, in medical schools, that could be remedied in part at least as a result of the influence of this Association.

RUDOLF J. NOER (Louisville, Ky.): A few months ago, in Chicago, a small group of us were discussing the question of liability, and Dr. Ravdin, who was present, urged that we all read a recently published book called "Ready for the Plaintiff," by Belli. The next day, I went across the street and asked the bookstore whether they had it, and they did.

They had two piles about four feet high. Apparently, they were expecting a large sale.

It is not pleasant reading, but I recommend it to you as a very informative and interesting discussion of many of the things that have been talked about this morning from the viewpoint of an attorney who has been very active in this field.

KENT L. BROWN (closing): I would like to thank the discussants. Some months ago, in talking to Dr. Carothers, I mentioned that I was studying the physician's role in legal medicine. We agreed that the problem needed study, but he reminded me that I had a "bull by the tail." This was no understatement.

In interviewing outstanding lawyers and physicians, the situation mentioned today was recognized as a "thorn in the side" of both professions. In fact there seemed to be no easy solution.

This complex problem must first be brought squarely before the professions. All should be made aware of its presence and take an active interest in it even though they are not personally involved. Secondly, groups such as this must take steps toward remedying the situation. An Association for the Surgery of Trauma seems to be a good place to start.

JAMES K. STACK (Chicago, Ill.): Brothers Wade and Carothers took a crack at Chicago, and I would like to remind them of a judge who started out in Cincinnati and became so famous that he went to New York. He was asked one time how he arrived at these terribly difficult decisions. He said, "Well, I listen to the plaintiff's testimony, and then I make a decision."

Then, the question was asked as to whether or not he listened to the defendant's testimony, as well as the plaintiff's testimony. He said, "I used to do that, but I got all confused."

Preventable Accidents

F. J. SCHLINK,* *Washington, New Jersey*

PREVENTION of accidents involves human and economic considerations of great scope and importance. Many steps and many media of information and education are needed to minimize the incidence of accidents in and about the home. First and most important is the better education of the citizen who has been dropped, as it were, into a complex mechanical and electrical civilization without educational preparation for the perils that surround him. Even grown men and women are usually not aware of the menacing dangers to which they are exposed by conditions of modern living until after they or some member of their families have been subjected to accident or injury.

The dangers are particularly great for the average housewife and her young children who are exposed to the mechanical dangers of washers, wringers and dryers, rugs sliding on glossy floors, doors closing on little fingers, toys with parts that can puncture the skin or eyes, or be swallowed. There are a host of electrical hazards, rapidly increasing in number and severity with the speedy multiplication of appliances in recent years. (The production of major appliances alone is now around $8 billion a year.) Each year many women and children suffer at home electric shocks of lethal strength, or of strength sufficient to cause a fall from a chair or ladder, or to knock a pan of boiling water or hot grease from the stove, perhaps upon a young child below.

There are hazards of fire due to curtains blowing over a gas flame, an electric heater set close to a bed or upholstered chair, or overturned upon a rug by accident. Grease blazes up suddenly in an oven or in a fryer. Undetected leaking gas sometimes causes explosions that destroy a whole house and spread death and ruin in their wake. Occasionally pipes or a hot water boiler, or a pressure saucepan, or an aerosol can of the kind used for paint or insecticide will explode from excessive pressure. A great many fires and explosions follow careless use of gasoline and kerosene, and stoves that are inherently unsafe in design.

Many of these mechanical, thermal and electrical accidents can be prevented by better education of consumers, chiefly in some of the simple principles of physics, mechanics and chemistry; these principles should be taught to all high school students and to students in teacher-training institutions.

A surprising number of accidents and fatalities are due to ignorance of manufacturers who make products for home use, unaware of the numerous physical and engineering problems involved, and by failure of manufacturers to employ qualified technical men to design their appliances and to set up adequate production line tests and inspections. Electric broilers or "rotisseries" of two leading makes tested by Consumers' Research were found to have a dangerous degree of "built-in" shock hazard; broilers, moreover, very often contribute to the overloading of wiring circuits in walls and partitions which can set fire to the house.

Portable electric water heaters with exposed or unprotected live wires have caused many deaths of unsuspecting persons in bath tubs. Electric hand drills and power saws often involve gross hazards, both mechanical and electrical. Electric blankets and heating pads have caused many severe burns of children or

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invalids and have even set bed clothing on fire.

The design of gas and electric stoves is often such that knobs and controls can be reached and burners turned on easily by a young child. On many stoves, controls are not identified in relation to the burners and the off position of controls is not clearly shown; thus, escaping gas may accumulate and cause fire or explosion, or an electric unit may be left turned on. Switches on many appliances are poorly marked or not marked at all, and for the most part switches open only one side of the line so that parts of the appliance or an electric stove are left live, although the homemaker assumes that when the appliance is "turned off" she is in no danger of receiving a shock. Gasoline and electric power mowers and electric lawn edgers are particularly dangerous tools for the men and boys about the house and for children nearby; the power mixer has a corresponding place in causing many injuries to women and children indoors.

Even the hazards of ionizing radiation have entered the home with the development of brushes for removing static electricity and dust from phonograph records, brushes which contain a strip of radioactive polonium on gold foil, or radium sulphate, without even a warning to adults of the extremely deadly nature of the active material. Such a substance may easily find its way into the mouths of young children.

There have been a number of recent deaths of small children due to so-called portable television sets that have an unsafe circuit combined with a conducting metal case. It is estimated that 3,000,000 television sets and 75,000,000 radio sets are in service that have been built according to designs that make them a direct or potential shock hazard.

The amount of electric current that can be passed through the body without danger of death or injury is surprisingly small, one-thirtieth the current that passes through a 25 watt incandescent lamp. No more than 9 milliamperes is safe for most men, 6 for most women. No one knows what the safe figure may be for a young child; possibly it is no more than 2 or 3 milliamperes, or $\frac{1}{100}$ of the current through a small lamp. The voltage is not important. Alternating current potentials as low as 12 to 15 volts can cause death when there is a combination of unfavorable conditions.

The shock hazard problem is particularly troublesome, because only a few engineers in the electrical manufacturing industry are aware of the many factors involved, and only the larger manufacturers and those with unusually well informed technical staffs subject their output routinely to careful tests that would eliminate nearly all the potentially dangerous appliances. Many deaths by shock have occurred simply because the manufacturer was not technically informed or qualified to engage in production of any electrically powered tool or device operating at 110 to 220 volts.

An ophthalmologist in New York state was killed in 1953 by shock from a drill sold by a big mail order house; the drill appeared to have the approval of one of the leading national appliance testing laboratories. A drill of the same make and model purchased by Consumers' Research for test a few months later was found electrically dangerous.

The consumer should be advised not to purchase and use any electrical device or appliance, however simple and safe it may seem, that does not bear indication of the approval of the Underwriters' Laboratories or of the Canadian Engineering Standards Association, and he should not use any appliance which does not clearly specify current, wattage, voltage, and other data sufficient to assure the use of the appliance under safe conditions and without danger of overloading household wiring systems. It is especially important that all larger electrical appliances used in the kitchen or laundry should be securely and permanently grounded. Appliances, particularly the smaller ones, should be disconnected by pulling the power plug when the job for which they were used is completed. Appliances left connected but out of use have caused many deaths. The use of electrical equipment of any kind in a bathroom is always dangerous and it is important to arrange wiring so that no switch, pull-chain, or lamp socket can be reached from a position in the tub, shower or at the lavatory.

In a few states and cities, there are laws and regulations which prohibit the sale of electrical devices which have not been approved by a state or city bureau or laboratory; such regulations represent a step in the right direction, but it must be granted that setting up a host of local approving authorities presents grave disadvantages. Nevertheless, localities should

exercise the responsibility of prohibiting, at least tentatively, the sale and use of certain power mowers, home electrical and mechanical appliances, highly corrosive, flammable or explosive chemicals, highly flammable children's garments, and dangerous toys, when these are of inherently unsafe design or workmanship. An effective safeguard against many kinds of accidents is to consult appropriate pamphlets and special bulletins of the National Safety Council. Articles that appear regularly in *Consumer Bulletin* are also directly useful as these report the results of careful tests on a great many common electrical and mechanical appliances and appraise their designs from the home safety standpoint in terms of brand names and model numbers. Rather often Consumers' Research finds important appliances unsafe or even outright dangerous; this applies even to a substantial number of appliances that were found acceptable by one of the approval agencies mentioned. Moreover, Consumers' Research reports regularly on articles which are not tested by any of the approval agencies or which, if they have been tested, were found deficient in some way affecting safety. A great disadvantage of the present methods of all the "approval" and listing agencies, including laboratories of so-called consumer magazines, is that if an article is not found safe or satisfactory, no warning is given to the public about it even though the faults may be of a sort to cause serious injury or even death to some users. Twenty-five years elapsed after first published warnings by Consumers' Research on the highly poisonous nature of the much used and highly toxic solvent and fire-extinguishing liquid, carbon tetrachloride, before the Health department of one of our largest cities first issued public warnings and announced requirements for cautionary labeling appropriate to the great toxicity of CCl_4 and mixtures containing it.

Schools often give a good deal of time to prevention of injuries by automobile and by familiar sources of danger such as careless bicycling, misuse of firearms and the like, but few schools deal effectively with the problem of injuries in the home from mechanical, electrical and heating appliances; moreover, the information they impart is likely to be general rather than specific and directly usable by the child and his parents. Much needs to be done to expand and render more concrete, direct and practical, the work of the schools in safety education, and particularly to show the teachers how certain dangers can be effectively demonstrated to groups of children.

Clothes wringers and food mixers are among the most common causes of injuries in home use of mechanical appliances. Just two Los Angeles hospitals, some years ago, reported having treated 305 injuries caused by wringers. It would be easy for the teacher to demonstrate how these two appliances can maim the homemaker or her young child, and how the wringer especially, can cause grave disabling injuries, even death. The dangers of electric shock can be shown by simple, safe means, which can cause no injury to the child but will teach him the feel of a very weak leakage current from a hazardous appliance and show what physical circumstances, such as dampness of floor or ground, or proximity of piping of other grounded metal surfaces in the kitchen will render the danger more likely to strike.

Especially needed is more discussion of the problem of hazards by home economics teachers, whose work naturally deals with appliances for cooking and cleansing but who for the most part have only very limited preparation to help young people guard against needless injury. To tell a high school girl or boy that one person a day, usually a women or a child, is killed in the American home by electric shock, is not nearly as convincing proof of need for care as to demonstrate how electricity escapes from its intended path through imperfect insulation into the body of a person standing on a damp floor or dewy grass playing with a badly constructed television set, radio or record player, or preparing a meal with the use of an electric skillet of an unsafe design.

The press can help greatly by telling the details of the causes of home injuries, especially when they are a bit out of the ordinary. This was done in very exceptional fashion in connection with the recent death of a young child, caused by electric shock from a portable television receiver, in Skokie, Illinois. Newspapers in nearby Chicago covered the incident comprehensively and reported the type of receiver, the name of its manufacturer and details of the findings of the board of experts who investigated the case thoroughly so that

parents of other children might know of the danger and take steps to guard against it.

Physicians can help the cause of accident prevention by reporting to the press instances of important causes of injury that come to their notice when the information would be of a nature to help safeguard other potential victims of injury from the same or similar causes. Parents who read in their home town paper how children of others have been injured or killed by climbing into a washer or dryer, refrigerator or freezer, or by handling a power tool hardly safe even in the hands of an adult, will learn, in time, to apply the information for the benefit of themselves and their families. Most people are convinced only by learning of specific instances; only a very few are educated by being exposed to general principles expressed in the cautious, carefully qualified language of scientists, engineers, college teachers and medical practitioners.

The lives of many depend upon their being helped by teachers, physicians, welfare workers, Boy and Girl Scout and 4-H club leaders, motion pictures, exhibits at county fairs and cartoon strips, to see how an injury or death can occur in their own homes by some unforeseen conjunction of a small child, a housewife or an enfeebled grandparent and a potentially dangerous toy, household tool or appliance. Work of striking value in this very field is done by the National Safety Council and its numerous constituent bodies, state and city councils under its general guidance and direction, and through their work in enlisting the interest and aid of 4-H clubs, and home economics and vocational education teachers.

Distinguished too, are the safety programs and publicity of The Association of Casualty and Surety Companies, American Mutual Liability and Fire Insurance Companies, John Hancock Mutual Life Insurance Company, Prudential Insurance Company of America, Insurance Company of North America, The Home Insurance Company, Farm Bureau Insurance Companies, extension and home management specialists, agricultural engineers and others in state agricultural colleges and schools of home economics, National Association of Home Builders, National Board of Fire Underwriters, National Fire Protection Association, Underwriters' Laboratories and the United States Coast Guard.

There are no doubt many other sources of valuable safety pamphlets and periodicals on home safety but those named have produced material of the greatest importance and usefulness to all in the field.

One of the best books ever published to foster safety in the home was a Bureau of Standards Circular, "Safety for the Household," first published in 1918, and again in 1932 and 1947. There is great need at this time for an equivalent book which might be called a Handbook of Home Safety written especially for those whose work it is to teach, supervise and indoctrinate people working in home safety. It is unlikely that the Bureau of Standards will continue the valuable work in this field which it carried on in earlier years. On that account, it is suggested that steps should be taken by medical associations and major insurance interests to provide for a rather comprehensive publication on home safety for the guidance of teachers, state and city health departments, builders, writers and others. A grant of $35,000 to $40,000, I estimate, would suffice to provide for the preparation of such a book, of about 200 pages, which could probably be made to sell at the cost of printing and mailing, at a charge of about 75 cents a copy. An increase of this price by 10 to 20 per cent would provide a well illustrated edition of the book with attractive pictures and use of color for greater interest to readers.

The Practitioner and Prevention

GEORGE M. WHEATLEY, M.D., M.P.H.,* *New York, New York*

IT is an honor to participate in this discussion to suggest how The American Association for the Surgery of Trauma can contribute to accident prevention. It is hardly necessary to tell this group that trauma following violent and unanticipated contact with physical forces in the environment is the leading cause of death in persons under thirty-five years of age. Last year the 95,000 accidental deaths and nearly 10,000,000 injuries represented a cost to the public of an estimated $11 billion. Fortunately, your trauma group has contributed significantly to advances in the surgical management of injuries, which means that many more accident victims are being treated with low mortality and a minimum of residual disability and disfigurement.

We must recognize at the outset that the prevention of injury is a much more complicated undertaking than the prevention of most diseases. Nevertheless, I am confident that the experience derived in the prevention of disease can be applied with appropriate modification to the prevention of trauma. I think we should recognize that prevention has several gradations. What can be called *primary* prevention is the avoidance of the accident, recognition of a potential accident situation and its correction. For example, eliminating a blind driveway, repairing a broken step and removing debris from a playground are examples of primary prevention. I would consider *secondary* prevention to be avoidance of injury and death. Thus your efforts to improve surgical handling and to encourage proper first aid are in every sense of the word prevention.

MEDICAL LEADERSHIP NEEDED

The conviction is growing among those concerned with accident prevention that medical leadership is needed. It is gratifying to observe the response of organized medicine to this. I have already referred to the leadership of your own trauma group and I expect you are all familiar with the concern of the American College of Surgeons, particularly through its Committee on Trauma, especially its study of automobile injuries. Only last week it was my privilege to participate in a top level meeting with officials of the American College of Surgeons and your Association and the National Safety Council to plan how these groups could work together. The American Association of Plastic Surgeons has a committee concerned with the prevention of accidents. The American Medical Association has for some time called attention to the importance of this problem particularly through its Journal. The organization with which I am most familiar is the American Academy of Pediatrics. Its Committee on Accident Prevention has been active since 1950. Through a national as well as state committees it has carried on a program which includes fact-finding surveys, special studies, round table discussions, papers, exhibits at national, regional and state medical meetings, and the preparation and sponsorship of publications dealing with prevention in lay as well as professional journals. In cooperation with the Academy's Surgical Section, it has prepared statements covering the emergency management of childhood skeletal trauma and burns. Both of these statements have been endorsed by the Committee on Trauma of the American College of Surgeons and have been widely distributed to lay organizations including the Scouts and camp groups.

Let me give you one or two more illustrations of how this Committee has carried out a program of prevention. An early activity was a survey among Academy members to secure information on the types of accidents seen in pediatric practice. The object was to deter-

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mine which hazards to children might lend themselves to control through engineering and standardization of manufacture. After analyzing the results of the survey it was clear that the problems of poisoning and burns should have immediate attention. Half of the cases in the survey were found to be poisonings and there were many serious burn accidents.

As a follow-up of this finding, a nationwide sampling was made to learn the types of poisoning seen in pediatric practice. Of the reported cases, accidental poisoning by drugs led the list, accounting for 43 per cent of the total cases, with aspirin ahead by a wide margin. Kerosene came next, accounting for 16 per cent of the cases. The remainder was made up of literally hundreds of common household agents. This led to the development of poison control centers for treatment, prevention and research, and a manual on the treatment of poisoning.

The first such center to be developed was the Chicago Poison Control Center. This pilot demonstration aroused such nationwide interest that poison control or prevention centers are now established in some 102 communities under the leadership of local physicians and health officials.

The latest development in this field is a national clearing house to aid local centers through collection of case reports nationally, for exchange of information, for professional and public education, and for research and prevention efforts.

As a further illustration to show where this information-gathering approach can lead, the American Academy of Pediatrics and the American Medical Association's Committee on Toxicology held a meeting with the leading manufacturers of aspirin, and the following recommendations were accepted by the industry:

1. Labels of salicylate-containing medicinals should bear statement of: "Warning: Keep out of the reach of children."

2. Labeling should withhold specific dosage recommendations for children under the age of three and, instead, state: "For children under three, consult your physician."

3. Children's aspirin should be of uniform strength, preference being 1¼ gr. per dosage unit (present range is from 1 to 2½ gr.).

4. Manufacturers should hold down quantity per package unit and develop containers that would resist opening by small children.

5. There should be wider and more effective use of educational means to inform physicians, pharmacists and consumers of the hazards involved in accidental ingestion of salicylate-containing preparations.

A survey just completed by the Proprietary Association shows that 41 per cent of its members now use on their drug labels a caution phrase similar to: "Keep all medicines out of the reach of children." Another 22 per cent of the members plan to do so in the near future; 25 per cent have not yet reached a decision, and 12 per cent do not intend to do so, in most cases because of the nature of their products.

Another by-product of the survey was a joint project with the American Standards Association to establish safety standards for (1) the flammability of textiles for children's clothing; (2) the labeling of paints and other coating materials to discourage the use of toxic substances on furniture and toys used by children; (3) the design of harnesses and sleeping garments to avoid strangulation or suffocation; (4) the design and manufacture of wooden furniture, baby carriages and strollers to minimize the possibility of injury resulting from their use.

Flammable Clothing. Progress has already been made on these projects: The American Standards Association subcommittee on flammability of textiles has initiated a study of the types of clothing associated with burns in children and has enlisted the aid of the National Fire Protection Association. A form to be used for collecting information on flammability of fabrics has been devised and is being pilot tested in Boston with the cooperation of a group of surgeons and the burn services of several Boston hospitals which secure samples of clothing involved in burn cases at the time patients are admitted to the hospital. The cloth is then tested for its degree of flammability.

Safe Paint. The subcommittee for the development of specifications for paint has recommended that a level of 1 per cent or less in lead content be considered safe for use on toys, furniture or interior surfaces that children might chew. This standard has already been used as the basis for a new ordinance in New York City, which requires that paint containing more than 1 per cent lead must have

a warning label stating that it is not to be used for the above mentioned purposes.

THE TASK AHEAD

These are a few examples of the organizations and the type of work which some groups in the profession are carrying out, but we have barely started. Prevention is based on adequate knowledge of causation and there are large gaps in our understanding about the way accidents occur. We know little about the circumstances which trigger accidents. We are only beginning to scratch the surface of such questions as the relationship between accidents and health, personality, behavior, drugs and many other factors. Your Trauma group can make a major contribution by cooperating in the study and investigation of accidents. You are actually closer than anyone interested in this problem to the unhappy chain of circumstances which results in an accident. Of all the professional groups and authorities, you are the first to see not only the tragic result but also the events surrounding the accident while memory is still fresh. Although your immediate and main responsibility is the proper treatment, nevertheless, you have an opportunity here to make an invaluable contribution to the causation of trauma. You can cooperate with other authorities in the investigation of cases. In fact, you can encourage such studies. I know that this is already being done by some of you in connection with the Cornell crash injury project. I hope that this valuable activity will serve as a pilot program for other investigations. I would like to suggest that traumatic surgical units set themselves up as data-collecting stations. If there were fifteen or twenty such centers or stations in the country which collected a few basic facts on the type of injury and the agent which caused it and reported it to a central statistical unit, we would have the beginning of an intelligence service concerning trauma. This would be comparable to the reporting systems which have been developed for certain diseases. Trauma has reached such, so to speak, epidemic proportions that we can no longer afford to wait for a paper to be written and then published a year or so after the author has collected fifty or sixty cases from his own experience, to discover that a certain type of power equipment or a procedure for handling some process is producing an unanticipated number of injuries. This network of cooperating surgical services not only could become in time centers devoted to setting standards for the better treatment of trauma, but also would play key roles in furnishing data for programs of prevention. While waiting for this kind of a development to take place, individual surgeons can contribute to the prevention of accidents. Let me give you a few examples of organized efforts all over this country which owe their start and much of their success to the leadership of individual pediatricians.

In Cincinnati, Kotte has played an active part in safety work in his own community through membership on the Board of the Greater Cincinnati Safety Council and through his chairmanship of an active group organized to campaign for home safety.

Arena, at Duke University, has been one of the leaders in focusing attention on the problem of accidental poisoning in children and has played an active part in stimulating the interest of North Carolina physicians in accident prevention. Dietrich, of Los Angeles, whose leadership has been nationwide, has contributed particularly through his writing.

Starbuck, in Massachusetts, spearheaded a child accident prevention program in New Bedford which is proving very successful. A report of the New Bedford program [1] stated that "The program . . . would not have come about except for the medical leadership . . . and the sponsorship of the Medical Society and St. Luke's Hospital."

Some of you may be asking yourselves what you can do as an individual surgeon to prevent accidents to children. I can tell you three things at least: (1) You can be more inquisitive about accidents; (2) you can set an example; (3) you can initiate or encourage community efforts.

Encourage Investigation. Case histories are valuable but relatively neglected sources of data for prevention. As I have already said, daily your experience places you literally at the most strategic spot to study why and how accidents happen. As an example, when a mother calls you to care for her son's badly lacerated knee, if you include in the treatment investigation of the circumstances of the

[1] Rice, G. R., Starbuck, G. W. and Reed, R. B. Accidental injuries to children. *New England J. Med.*, 255: 1212, 1956.

accident, by your questioning and by prodding others to investigate you might discover, for example, that it had occurred in the school gym; that the knee had been jammed against the projecting metal edge of a torn radiator cover in a bit of horseplay while the gym instructor was not in the room, and that the torn cover had been an existing hazard for some time—an invitation to trauma. Correction of this accident-breeding situation is as important as an immunization.

A hundred other possibilities for investigation and correction will occur to you. Not that you must or should do it alone, but you do have the necessary facts to spur others who are more directly responsible to take the necessary corrective action.

Another personal thing you can do is to teach safety by use of appropriate educational material available through many organizations, including the National Safety Council. Some physicians find a bulletin board in their waiting rooms a good place to get over some important lessons. I doubt if there is a better time to emphasize safety than such advice as news items or safety publications placed where the patient or the family can read it if they wish. In a survey we made several years ago, we learned that about 80 per cent of the members of the Academy of Pediatrics carry on a planned safety educational program with their private patients.

Set an Example. Double-check your own office or hospital for safety. I suppose surgeons are more conscious of accident hazards about the hospital than other physicians. They have learned from anesthesia accidents. Is the patient adequately safeguarded from falls? Are nurses and other attendants given some safety education? In using radiation apparatus, are you careful to prevent exposure to your person and assistants? Are medicines and other potentially toxic materials used in your office or hospital safely stored and well identified? Your safety campaign might well begin in your own everyday surroundings—and do not forget your own home.

Encouraging a program of careful and detailed record taking in your hospital's emergency room is another way in which you might, working through your own specialty, play an important role in accident prevention. In case presentation and discussions you can bring out (in addition to the treatment) ways to prevent trauma.

Give Leadership in Community Efforts. You can give encouragement to local groups interested in undertaking community safety programs. Does a local parent group or service club need a doctor to address them on accident prevention? Do voluntary health and safety agencies need aid in planning their activities? An increasingly large number of physicians are active in their local safety councils and are cooperating with other community groups. The opportunities to help are many.

When the physician speaks—and this is particularly true of a surgeon—people listen. When you address a parent group or make a radio talk or participate in a round-table discussion on safety or any health subject, you give it authority and prestige as well.

As surgeons you have, by training and experience, a special competence to contribute to the study of accidents. You have also by virtue of these qualifications the responsibility of leadership, as individuals and as an organization, to participate in programs of prevention. I would like to think that the individual tragedies with which you are all too familiar will impel each of you to take an increasingly active part in this work.

Medicine and public health have played major roles in the battle which man has been waging with his environment in the past fifty years. This struggle, resulting in a remarkable degree of control, has been directed against the communicable diseases. The means of control have been sanitation, immunization and the newer antibiotics. Today, thanks to technological progress, machines and toxic chemicals loom as greater threats to life than germs. The protection of the individual from these and other causes of injury is a challenge worthy of the skills of modern medicine and public health.

Accidental trauma, of all the leading causes of death, offers the most promise at the present time for further substantial improvement in life expectancy.

The National Safety Council, Policies and Program

THOMAS FANSLER,* *Chicago, Illinois*

THE National Safety Council welcomes the interest of medical men, and, perhaps, especially surgeons in the problems of accident prevention. The Council welcomes this opportunity to set forth its policies and programs.

The National Safety Council was established in 1913, just forty-four years ago. An executive secretary and two clerks comprised the staff. The year 1913 was two years after the first state law on workman's compensation was passed, in Wisconsin. The social theory placing financial responsibility for injury on the employer's shoulders soon became acceptable throughout the country, and employers became more and more interested in learning how to prevent these injuries which the law was compelling them to pay for. The National Safety Council formation was initiated by some seven companies including two steel companies, a railroad and the Pullman Company. It was industrial accidents or occupational injuries received in the course of employment that concerned these people at first.

Early in the history of the Council, a study committee was formed whose purpose was to analyze causes. You doctors will be interested to know that the first study committee found that some three out of five—or 60 per cent of the accidents studied—were easily explainable in that either the conditions were hazardous or the worker did something he should not have done. But in nearly 40 per cent of the first cases studied, the causes or circumstances were obscure, and so these cases were labeled "acts of God." Apparently God is a little more kindly nowadays, or else safety engineers are smarter than they used to be. At any rate, nowadays we do not go around blaming God for things right under our own control. A small fraction of 1 per cent are now labeled acts of God. Even in cases of windstorms, hail, hurricanes, etc. (which might truly be called acts of God), we know that even if the storm can't be prevented, usually the damage both in property and in loss of life can be materially decreased.

Accidents can be prevented. Our industrial experience has demonstrated that much. The study of causes and the application of sound preventative measures has in the past forty-four years resulted in a gratifying decrease in accident incidence, both in crude numbers and in rate.

For many years the National Safety Council concentrated on industrial safety, but in the 1920's the automobile began to make its impact on American life. Impact in more ways than one: impact on the people who weren't quick enough to get out of the way and impact on our social habits and customs. In the early twenties, a staff of traffic engineers and statisticians was added to the Safety Council roster. Their job was to develop traffic safety programs, and our present traffic safety activities extend into forty-eight states and 1,200 cities. Also in the twenties an educational department to deal with schools and colleges was added; then a Public Information Department; and much later, in 1944, a Farm Safety Division and a Home Safety Division were added. And just recently, programs have been launched dealing specifically with women's groups, organized labor, and church and religious groups.

The Safety Council began as a membership organization. It still is a membership organization. The great bulk of our income (85 per cent in all) comes from annual dues from our 12,000 members and from the materials and services which we prepare for them. Only 15 per cent of our annual income is in the form of contribu-

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tions. Our corporation members—and you must bear in mind that General Motors Company with over 400,000 employees is just one member—our corporation members have a total employment of about 15 million workers.

But besides being a membership association, the National Safety Council is also a public service organization, undertaking a wide variety of activities in traffic safety, home safety, farm safety and school safety, activities which are not self-supporting. The costs of these activities are far greater than any income derived. Our large industrial members (Dupont, A.T.&T., U.S. Steel, Union Carbide, to name a few) are firmly behind this public service program, not only as good corporate citizens, but also because they realize that accidents off-the-job are a serious drain on manpower.

In 1953, the Congress of the United States granted to the National Safety Council a Federal Charter. This charter stipulates that the Council must report annually to the Congress, although the Council does not receive any tax funds or Federal appropriation from Congress. The Federal Charter was, perhaps more than anything else, a recognition by Congress of the increasing importance of accidental injuries as a problem affecting the health and welfare of all of the people of our land.

The Safety Council, then, is a privately supported membership organization with an extensive public service program. It is non-profit, non-governmental, non-political. It is a council in the true sense of the word—a cooperative association of groups and individuals working together for the conduct of safety activities. The task is gigantic, e.g., we face the necessity for moving some 60 million vehicles on 4 million miles of streets and highways without the appalling annual toll of 40,000 deaths and 1½ million injuries.

The Council is interested solely in accidental injuries and deaths and in devising means to prevent such occurrences. The Council undertakes to study the facts of accidental occurrences by collecting and studying accident records and by research. The Council undertakes to devise or to help devise various measures for accident prevention—engineering measures, educational measures and enforcement measures.

Sometimes this means model legislation. For a number of years the Council has been concerned with uniform traffic laws and ordinances. Sometimes this means developing or helping to develop various standards for safe design, construction and use of machines and equipment—machines and equipment used in the factory, or in the home or on the highway. The Council also participates in planning and executing various training and educational programs, and it produces needed educational and promotional materials such as magazines, leaflets, posters and so on. Finally, the Council encourages and assists the establishment and functioning of local safety organizations and state councils.

The above activities are planned and directed by the Council which consists of its members and allied groups and individuals. The Council staff is not the Council. The staff is simply the paid, operating body that carries out the programs and activities agreed upon by the members and their advisory groups.

A brief word about local safety councils before I conclude by stating the Council's creed. About 350 local safety councils are in existence. Some eighty of these are well enough financed, well enough organized and staffed so that we have chartered them as chapters of the National Safety Council. The rest are in varying stages of development. Some operate purely on a voluntary basis and meet only occasionally; others employ full or part-time organizers and clerical help. All of them, however, are autonomous. They all have their own local boards and governing bodies. They all raise their own money locally and spend the money to help solve local problems. The National Safety Council has no jurisdiction. These Councils have agreed to adhere to a set of policies developed by the National Safety Council. However, we exercise control only through advice, suggestions, consultation, and occasionally through cajolery and persuasion. For the American citizen locally is somewhat cantankerous at times. One of the expressions we hear most often is, "Those people up at National headquarters don't understand our local problems!"—a complaint that every national headquarters hears, even the Federal government.

Now, the National Safety Council welcomes the interest of medical groups. It seems to us that the Association for the Surgery of Trauma can be effective not only in patching up injuries, but also in helping in accident prevention, both as an Association and as leading citizens in

your communities. As a result of a request by your Association, a committee of our Board has met with a committee of the Regents of the American College of Surgeons to explore and develop ways of cooperative action. This is all to the good and can result only in more effective programs locally.

I believe that you will understand the Council better if I read four short sentences from a bulletin issued by our Board. It reads, in part, as follows:

"The Council's Creed"

"Safety is positive. It is doing things the right way. It is interest in the welfare of others. It is a contribution to good living, to good government and respect for law and order, to efficient production, and to the well-being of every individual."

Prevention of Trauma: A Joint Responsibility

JAMES L. GODDARD, M.D., M.P.H., *Washington, D. C.*

THE "joint responsibility" for the prevention of trauma is shared by the medical profession and the public health profession.

An article in the *Journal of the American Medical Association* (October 19, 1957) documents the recognition by the medical profession of its great share in this responsibility. Commenting on Bulletin 105 of the A. M. A.'s Bureau of Medical Economic Research, entitled "Accident Burden on Hospitals," the *J. A. M. A.* pointed out that "In general, the burden of accident cases is 7 to 8 per cent of the grand total for the 6,000 general and special hospitals in the United States. Presumably, the burden on physicians comes within the same range."

The *J. A. M. A.* editorial went on to pinpoint the basic reason for public health concentration on accident prevention by stating that ". . . fatal accidents outrank heart disease . . . as the number 1 destroyer of the working years of life in the United States."

In addition to the productive man-years lost and the drain upon the community providing care for the injured, which results in an unnecessarily high economic burden to the nation, the measurable costs (including property damage, medical and insurance expenses, and loss of wages) exceed $11 billion per year.

In my discussion I shall attempt to focus on certain major elements in the prevention of accident trauma by treating briefly four significant categories of responsibility: emergency care, definitive treatment, patient guidance and community participation. It will be clear that while all of these are cooperative undertakings, the emphasis on the roles of the private physician and the public health worker varies from category to category.

EMERGENCY CARE

There are several aspects of emergency care that merit attention:

First Aid. It is generally agreed that there is need for the extension of first aid training to more members of our communities. It would be impractical to suggest that everyone be trained to the same degree of proficiency. It is, therefore, most important that the most attention be given initially to those groups which are likely to be concerned with emergencies. The police, highway patrolmen, firemen and ambulance drivers should be experts in first aid. In many communities training for such groups has been provided and physicians have contributed their time and efforts to such activities. As the group most concerned with the definitive care of the injured you can best serve the interests of your patients by becoming involved in such training activities.

Care and Transport of the Accident Victim. Much emphasis has been placed on the importance of proper handling and transport of the injured person, yet in many communities there is little or no supervision given to this phase of emergency care. Not only do many of the personnel involved lack the necessary training but also all too often they are handicapped by not having the proper equipment to handle the job that confronts them.

A well organized rescue squad can make a significant contribution in your community. Since this is an expensive operation, it is one that will require considerable justification. Again you are uniquely suited to support such an effort by bringing this matter to the attention of civic groups, responsible public officials and the members of your local medical society.

There is also the implication of continuing supervision of training inherent in this suggestion. The degree of competency of such an organization is indeed a reflection of the degree of interest you develop and maintain.

Emergency Room Care. In most communities definitive care begins at the time the

injured person enters the emergency room. It was heartening to read of Dr. Harrison L. McLaughlin's recent forthright discussion of this matter. Dr. McLaughlin referred to the era of the emergency ward, chaotic with "the indecisions and inadequacies of a junior resident" and said that the era is drawing to a close.

The organization of emergency services within the hospital is the responsibility of the medical profession. The importance of properly carrying out this responsibility is well known to each trauma surgeon. Not only must the facilities and equipment meet the most exacting standards but also, even more important, the supervision of the emergency room staff.

My own experience in this field is indeed limited, but I had the privilege a few years ago of participating in a course in hospital management. This matter of supervision was discussed at some length by the director of a Boston hospital.

He described very vividly to our group the almost chaotic conditions created by a local disaster which caused many accident victims to be rushed to the hospital at the same time. Subsequently, the hospital organized an operational plan to handle emergencies involving multiple victims. An important feature of this plan was the assignment of the most experienced and most capable surgeons to the emergency rooms. Here, the director said, was where the highest degree of competency was required.

It might then be worth while to look critically at your own hospital emergency rooms. Is there a plan of operation for handling victims of disasters (motor vehicle accidents with eight or even ten persons injured are not too infrequent)? Are supplies adequate? Can you call into action a well organized team which will function smoothly and efficiently?

DEFINITIVE TREATMENT

Improvements in survival rates have been phenomenal in the past twenty years. Many factors have contributed to this improvement. Among the more significant, the following may be listed: (1) Maintenance of high standards within the surgical profession and better training. (2) Improvements in anesthesiology, new anesthetic agents and improved technics for safer administration. (3) The availability of whole blood and its intelligent use. (4) The development of plasma expanders. (5) The discovery of the host of antibiotics which have reduced secondary complications to a minimum and prevented many deaths. (6) The development of new surgical procedures which not only save lives in many instances but also, perhaps of equal importance, minimize the effects of non-fatal injuries, thus reducing the number and the degree of disabilities. (7) The improvement of hospital facilities and equipment.

Still further improvements can be anticipated as skills increase and research provides us with new technics. Ultimately then, we can anticipate reaching a plateau where further advancements in the process of "patching up" damaged bodies cannot be expected.

The main effort must then be in the field of prevention of injury. It is in this area that we have made only a feeble beginning and are most anxious to enlist your support and active cooperation. You can begin in this area by utilizing your contacts with patients who seek your advice on other matters.

PATIENT GUIDANCE

The traditional patient-physician relationship gives you an opportunity denied the rest of us—the ideal setting for patient guidance in accident prevention. As Dr. Ross McFarland has stated, "The physician should take the initiative in identifying the causes of accidents leading to their occurrence and indoctrinate patients with the principles of accident prevention while they are being treated."

The physician can not only "teach while treating injuries" but also can warn, advise and counsel in anticipation of potential future accidents. By this I mean that he can discuss frankly with patients any disabilities which could interfere with the ability to drive a motor vehicle, for example. In addition to the obvious hazards, such as inadequate vision and hearing, there is a whole range of chronic conditions that can at any time seriously interfere with an individual's control over a motor vehicle. One thinks immediately of diabetes, epilepsy, and heart and neuromuscular conditions, to name but a few. The physician's advice to patients having such disabilities, tactfully but frankly conveyed, will be heeded in connection with driving behavior as readily as in connection with other aspects of daily life, although the patient will not always, on his

own initiative, note the all-important relationship between his condition and his driving capacity.

Similarly, when prescribing drugs the physician should be as alert to warn his patient of possible implications in relation to driving as he always is to suggest the hazards of other side effects. The Highway Research Committee of the National Research Council has pointed out that "*more continuous attention* from moment to moment is required of the motor vehicle driver than of the operator of any other type of transportation, including the airplane." Any reaction from a drug which affects that "continuous attention" is surely a most significant side effect. We should, in other words, be more concerned with the potential risk of tranquilizers (for example) for motor vehicle drivers than for airplane pilots.

What has been said concerning motor vehicle accidents applies, of course, with equal validity to other important categories of accidents such as home accidents.

COMMUNITY PARTICIPATION

Supplementing and strengthening his personal contribution to the cause of accident prevention, the physician is in a position to function most effectively through community participation.

This community participation can take several forms. There is in every community a need for a clear understanding of the accident problem. In several communities and in one state, reports of injuries treated in emergency rooms and physicians' offices are collected by the health department. Analysis of this data forms the basis for an effective educational campaign. This is a classic example of assumption of joint responsibility. I should hasten to point out that there are other organizations which have sponsored such activities. Local safety councils and service clubs are examples of these groups.

The physician's work will carry weight in any community when he lends his support to movements for improved enforcement of traffic laws. As an extreme example, it was even suggested in a recent medical newspaper column that physicians would make valuable volunteer observers to report traffic violations and examples of unsafe driving to the proper authorities.

One of the most effective technics for cutting the accident rate in any community is driver education. Organized at the high school level, this activity has demonstrably improved teenage driving habits (reflected in reduced insurance rates). Equally gratifying results can be anticipated from adult driver education. Through your P.T.A. you can work for high school driver training; through your service club or other local group membership you can work for adult driver education.

It may appear to you that I have strayed at times from my assigned topic of our joint responsibility in the prevention of trauma, or that I have emphasized the medical more than the public health aspect of this responsibility. In stressing cooperative effort, however, I have really been talking about the public health approach to accident prevention.

The stimulation and guidance of community action to reduce the terrific toll of death and disability from accidents in this country is the role of the Public Health Service and of the state and local health departments.

Through education, both professional education and education of the general public, we hope to make a significant contribution to the cause of accident prevention in the years ahead. Only by enlisting the enthusiastic support of appropriate local groups can this education campaign succeed; and no group in the community is more vital to our effort than the surgical group.

You will find that every local public health officer in every community in the United States will be your strong and determined ally in all programs designed to improve the care of accidental injury and to prevent accidents.

Panel Discussion on Accident Prevention

MODERATOR WILLIAM L. WHITE: I know that there will be questions after this very stimulating discussion by each of the members of the panel. I will call on the members of the panel, or you may question them directly from the floor.

I have been handed the following question. The National Safety Council collects statistics yearly on the number and types of accidents. How can the members of this Association obtain this information? I am sure that is directed to you, Mr. Fansler.

MR. FANSLER: Our annual publication is called "Accident Facts." It is a ninety-six–page volume filled with columns of statistics which make mighty dull reading for the ordinary individual but very fascinating reading for anyone interested in the problem. Copies may be obtained by writing to me, care of the National Safety Council.

MODERATOR WHITE: I have a question for Dr. Goddard. To what extent is accident prevention properly a matter for federal legislation?

DR. GODDARD: That is a difficult question to answer, because it depends upon what aspects of the problem you are attempting to solve. In the last session of Congress, thirty-five measures relating to automotive safety alone were introduced. One such measure called for a governor to be installed on every car, limiting the speed to 50 miles per hour. One called for the installation of seat belts in every vehicle before it left the factory. Other safety measures were called for. These are just examples of the types of legislation that chronically are put into the hopper. I feel that there are some small aspects of the problem that can be handled by legislation but, in general, the best method of attack is through education of the individual and education at the community level.

We can legislate seat belts, we can legislate governors, but unless people want these things and are willing to use them, it will not do any good.

MODERATOR WHITE: I reiterate that statement. The legislative control of accidents is, after all, a passive type of immunity. What we are all interested in is a more active form of immunity, which is through education. If we can train people to be conscious of the hazards of accidents, then the chances are that they will lead their lives in that manner.

I have a question for Mr. Schlink. How can manufacturers of appliances be stimulated to take more care in the design and testing of their products so as to reduce the number of accidents?

MR. F. J. SCHLINK: I will try to answer that with some pictures.*

Here are three blenders. The center one is so designed that if a liquid spills from the glass container it will run over the motor and produce a shock hazard. The point is that the manufacturer might have at least envisioned this possibility, but he did not make any provision for it.

This is a switch of an electric fan of a very large manufacturer. You note that at the top is what used to be an insulator. This brass strip, which goes from the bottom to the top, is in circuit at 110 volts, and the insulator at the top, now broken off, was the only protection between the individual and a dangerous shock. A little foresight would have indicated that this was not a very good safeguard.

Here is an electric room heater with a new device which is quite useful. It shuts itself off if a dog or child knocks it over. This is both simple and practical, and an obvious improvement in heater design. Here is an example of a heater which has fallen on the rug. You can easily see that a house could be set on fire by this very simple accident.

Here is an electrical plug which is so weak that it crushed in the hands of the person who removed it from the socket. I have the pieces with me, if anybody would like to confirm what I say about its poor construction.

* Mr. Schlink illustrated his discussion with slides.

This is a poor man's shock hazard tester, so to speak, which is designed for high school teachers or students to build. It can detect a leakage of a very small amount of current, less than 0.2 milliamperes.

Here is an interesting piece of equipment. This design has been used for fifteen or twenty years and is still being made. It has three prongs which are a part of the circuit. When the plug is attached, it is possible to make contact with the fingers on the two outside prongs and get a full 90 volts through the fingers. A simple shield placed around the prongs would prevent this.

Now, to turn from the electrical to the mechanical, here is a perambulator designed for tipping the baby over backwards. As you can see, when a woman fills it with a heavy load of groceries, it becomes a highly unstable stroller. On the other hand, here is a well designed perambulator with the load just above the wheels so it cannot possibly cause the carriage to tip.

This is a test of floor-polishing machines. A shock-hazard-testing device enables us to measure the amount of electrical leakage current. Any appliance using water, and that includes washers and dryers, is dangerous because we set up a situation in which a wet conducting path is provided.

A mechanical hazard of an electrical mixer is shown here. The most common kind of household accident these days involves the electric mixer. This shows what might happen to the fingers. We know of one case in which a woman lost the tip of her tongue when she licked the icing off the mixer.

This is an attempt to make an electric mower safe, and it is a pretty good attempt. It is one of the first drastic approaches to this problem. I think I mentioned that this appliance was the principal cause of accidents to men and boys about the home. The only danger is that if a man wants to cut some extra tall grass, he will take off his safety device. Ordinary grass height can be handled quite readily with this protective device in place.

This is an even better approach by an electric mower manufacturer. Unfortunately, I cannot speak favorably of the electric mowers because they introduce certain shock hazards. With this mechanically ingenious device it is almost impossible to get the foot under the front or back. It is possible to get inside from the left or right side. This does reduce a large part of the dangers caused by the mower sliding back over the foot, slipping down a terrace or some accident of that type.

Here is a type of mower which is badly designed. These pieces on the rotor are an invitation to disaster because they can work loose and fly off with centrifugal force at extremely high speeds. I might add that the speed is half that of a revolver bullet. The results speak for themselves. Many people are killed by this type of accident. It does not take a very large object: a piece of bone left by a dog, a coat hanger or a slice of hose nozzle can cause such an accident. There is one case in which a piece of hose nozzle was projected across a street and killed a woman who was several hundred feet away.

MODERATOR WHITE: The next question I would like to direct to Dr. Wheatley. Can you give us some idea of the proportion of trauma cases which involve children and particularly the incidence of mechanical injury in children?

GEORGE M. WHEATLEY: I do not think there are any very good statistics on this point, but we did analyze the experience among the dependents of our own employees. I think, in our experience, we had 13,000 or 14,000 children. The proportion of those hospitalized and for whom claims were paid represented about 20 per cent of the hospitalizations for accidents. The percentage is low in that group because, as you can imagine, the most frequent surgical experience in children is tonsillectomy. I think tonsillectomies represent about 50 per cent of all the cases, but if you look at the claims outside of hospitals, about 80 per cent of all of the claims are injury cases. This, I am sure, would not come as a surprise to trauma surgeons. However, I think some people outside of the surgical field are astonished to find how important accidents are in the lives of children.

MODERATOR WHITE: I would like to ask a question of Dr. Goddard. Does your organization in the Division of the Public Health Department support any investigation or research in accident prevention? If so, how may this be arranged?

DR. GODDARD: We do support considerable research in terms of total finances involved.

I think this year we are supporting about $300,000 worth of research projects and accident prevention. We still have considerable monies available. One of the major problems is getting competent research investigators interested in this field. Competition for research talent is indeed great.

If any of you, as individuals or members of services, hospitals or universities, are interested in developing research projects related to accident prevention, I would be happy to either meet with you or send you the next instructions and forms as to how you can apply for research support. We have a great need not only for increased amounts of research in accident prevention but also for a better quality of research.

MODERATOR WHITE: Here is a question from the floor. I wonder if Mr. Schlink would tell us a bit more about the safety features that are necessary for television sets, the subject that he brought up.

MR. SCHLINK: The first thing is, do not buy a portable television set with a metal case.

Second, if you do have a television set with a metal case, it might be a good idea to have it checked by a qualified electrician to see if there is leakage occurring; there often is. It is typical of such sets that the chassis is at line voltage for one position of the plug. If you reverse the plug, it might not be. That is a weak reed to lean upon, because you never can tell when it is going to be re-reversed by someone. This type of set should never have been built, and anybody who has one should take precautions that it is kept away from children because they will make contact with anything if you give them a little time. They will provide the ingenuity with the use of a bobby pin, hairpin, paper clip or something. That will enable them to get inside the chassis to make contact with some electrically live part.

Incidentally, the other day, I discovered an appliance which had a warning on the back about how hazardous it was. A department store had serviced it and had pasted over the warning a job tag which recorded their activities in repairing it. Therefore, the person who would have been warned was no longer warned after the service man had finished his job. This proves that there are all levels of intelligence in the servicing problem.

I would like to make one more point. Local people should step in to act by regulations. This is an electric heating device* which has killed many people. In one year it caused one-third of all the deaths that occurred in bathrooms, because people used this device to heat the water in the bathtub or lavatory. Inside a perforated aluminum drum is an open chromium alloy wire coil. You have almost certain death for anybody who takes this into the tub and uses it to heat water. The instructions say not to do that, but instructions are not always included and people do not read them.

This device is so dangerous that if it were sold in your community it would be proper to call upon the Health Department to stop the sale immediately. In one case, the city judge ordered the man who sold these to buy back 150, many of which he had unloaded upon the local people.

Here is another potentially deadly device (and there are others that are almost as bad) which is very popular. It has the disadvantage that if you get water in a certain part of it, it also makes water in the bucket or glass live, so you can get a shock directly from that. This device is sold by the thousands by mail order advertising in big city newspapers. As far as I know, we were the first people to discover it had a shock hazard, because it had never been subjected to tests by the underwriters or other public agencies.

MODERATOR WHITE: Dr. Powers has some material on rural roadway accidents that he would like to present.

JOHN H. POWERS: I have very much enjoyed the remarks by the members of this panel, both because of their intense significance and importance and because of my own interest in this subject over a period which embraces a quarter of a century.

I would like to call to your attention the fact that the subject is one of major importance not only to those who live in metropolitan areas but also to those of you who practice in rural communities.

I reside in Cooperstown, New York, a little village in the central part of the state, and I have long been interested in the seriousness of the accidents which transpire in that area, agricultural accidents particularly, but also motor vehicle accidents. It may interest you to know that the mortality rate of rural accidents is exactly twice that of accidents

* Mr. Schlink illustrated his discussion with slides.

which occur in cities of 10,000 population or over.

Metropolitan New York, with 53 per cent of the population of the State, is responsible for 40 per cent of the fatal accidents. Cities of 10,000 inhabitants and over, with 23 per cent of the population, are responsible for 18 per cent of the fatal accidents. That is exactly the same proportion. Towns of under 10,000, rural villages, little country crossroads, also with 23 per cent of the population of the state, are responsible for 40 per cent of the fatal accidents—23 per cent of the population, 40 per cent of the fatalities. In other words, the mortality from accidents in rural areas is twice that in metropolitan New York and in cities with 10,000 inhabitants and over.

There is no question of the magnitude of this problem; two speakers have referred to it previously. Possibly, if you see some pertinent tabulated data on the screen, you will have a little better conception of its importance.* From ages one to four, accidents are responsible for more deaths than the two next most fatal diseases. Between five and fourteen years of age, accidents are responsible for twice as many deaths as the two most fatal diseases during these years. From fifteen to twenty-four (many of you have children between these ages), accidents are responsible for *four times* as many deaths as are the two most fatal diseases, which during this decade are cancer and heart disease. From twenty-five to forty-four, accidents are superseded only by heart disease as a cause of death in the United States.

I would like to show briefly a few data relative to motor vehicle accidents as they have occurred in the central part of New York State. You may or may not know that the first fatality from a motor vehicle occurred in New York City in 1899. Mr. H. H. Bliss stepped off a trolley car, was struck by a passing automobile, knocked to the ground, given first aid, taken to the Roosevelt Hospital, and died the following day.

During the next fifty years, that is, up to 1949, 1 million people were killed by automobiles. We are now well on our way toward the second million. It is estimated that this will require only thirty years at the present rate, and all indications suggest that this rate is not only not remaining static but also is increasing. I believe there were 38,000 fatalities from motor vehicles in this country in 1955. There were some 40,000 in 1956. I have no idea what they will be in 1957. It has been estimated by the National Safety Council that there will be in excess of 56,000 fatalities from motor vehicles alone in this country in 1965.

A current study of motor vehicle accidents in central New York is in progress but is not completed. Therefore, I must refer to a previous review for most of these remarks. This study included 492 accidents in which 607 vehicles were involved and 712 patients were injured sufficiently seriously to be admitted to the Bassett Hospital in Cooperstown; there were 2,891 known recorded injuries; twelve persons were killed at the site of accident and twenty-three died subsequently in the hospital. The head and neck were injured more frequently than any other part of the body, and shoulder and upper extremities with about the same degree of frequency as the hip and lower extremities.

We cannot cure this epidemic of accidents until we know what causes the disease. To whom do accidents occur? Where do they occur? Why do they occur? When do they occur? Only when these facts are known can proper preventive measures be instituted. In this respect accidents are no different from measles, mumps, or whooping cough save for the fact that they are far more important as a cause of death in this country. Regarding the age distribution of motor vehicle accidents in central New York, there is a sharp peak between the years twenty and twenty-four in both sexes. A similar peak between these years is seen in the accidents to boys alone. In girls the peak occurs between the years fifteen and nineteen. These statistics are comparable to data published by the Metropolitan Life Insurance Company which indicate that most fatalities from motor vehicles in the male sex occur at age twenty-one, and in the female sex at age eighteen.

In the seasonal distribution of rural automobile accidents, there is a tremendous seasonal peak during the month of August when conditions are most favorable and all America is on the highways. A fairly low incidence is apparent in November, December, January, February, March and April, when rural highways are at their worst, at least in our part of the state. Not only do more

* Dr. Powers illustrated his discussion with slides.

accidents occur during July and August but also more people are injured in each accident.

We wish also to know the most dangerous days of the week on the highways. This is fairly well established. Again more accidents occur and more patients are injured during the weekend than on Monday, Tuesday, Wednesday, Thursday or Friday. Saturday and Sunday are the most dangerous days of the week on rural highways, metropolitan parkways or transcontinental thruways.

Regarding the distribution of accidents around the clock, most accidents occur not after dark, not after midnight, but from 4:00 in the afternoon until 8:00 in the evening. There are many reasons for this fact; excessive speed, fatigue, anxiety to reach one's destination, and slow reaction time at day's end especially among those drivers who have been long hours at the wheel.

The same diurnal distribution is reflected throughout New York state. I thought possibly the lower curves might be a reflection of the situation in our rural area about Cooperstown. However, in 104,629 representative motor vehicle accidents transpiring in New York State in 1950, you see exactly the same type of curve, with peaks between 4:00 in the afternoon and 8:00 in the evening.

In a comparison of certain data from the series at the Bassett Hospital with New York State as a whole, 84 per cent of the cars involved in our series were passenger cars. Seventy-five per cent of them were going straight ahead; 63 per cent of the accidents occurred on dry roads, 69 per cent in clear weather and 60 per cent during the hours of daylight, not at night. They were not on muddy, slippery, icy, rainy roads, or in cloudy or snowy weather, but on dry roads in clear weather, driving straight ahead during the hours of daylight.

The figures for New York state are almost exactly the same, and they are identical so far as the weather is concerned.

Another thing which may interest you is the estimation by the National Safety Council that one of every two people now living has been or will be seriously injured in an automobile accident before he dies, if he is not killed by an automobile.

It seems to me that the members of this Association are in a particularly favorable position for the dissemination of such information to their patients and to their communities. Take time to talk about these facts to the students in the high schools, the Rotary Club, the Woman's Club. Legislation is fine; undoubtedly much of it is necessary. However, if these data were known, if your patients and the members of your communities could be impressed with these facts, and if a real effort could be made to enforce the currently existing traffic laws, accidents due to motor vehicles would immediately be reduced by at least one-half, and the attendant preservation of life and limb would be well worth your efforts at preventive surgery.

MODERATOR WHITE: Thank you, Dr. Powers, for your very cogent and enthusiastic remarks.

DR. CAMPBELL GARDNER: I am from Montreal, Canada. I hesitate to speak on this problem; everyone has done so magnificently, and I always hate to agree completely with the last speaker, but I am afraid I must for a number of reasons. About two years ago it struck us that a remarkable number of doctors were traveling around without an M.D. or some other significant symbol on their license plates. The excuse generally given was that this was to prevent their cars from being broken into for the purpose of stealing drugs. This rather puzzled me and, together with a number of other doctors both in the United States and Canada, we decided to investigate. The answer, usually is very simple. The average doctor is not trained to handle victims of accidents outside the hospital and does not wish to appear foolish if asked for help.

I think Dr. Kennedy has written twice on this subject. He said lately that after twenty years, three wars and numerous disasters the average medical school still gives no course whatsoever in the immediate handling of accident victims.

We felt that in addition to the aforementioned, it was vitally important to find out what the basic cause of accidents was, just as we have tried to find the cause of cancer infections and other diseases. We arranged a meeting in Montreal last year. I must say that at the end of it I was more than a little tired and confused. We had psychiatrists, physicians, lawyers and all sorts of people as speakers, including the Chief of Police of the city of Chicago, in order to find out just exactly what everybody knew about the cause of accidents. At the end of it all we did not find the

final answer but we did discover a certain number of things. We found out that most of the facts given by the last speaker were true and I need not reiterate them.

We thought, however, that in order to arrive at a true and final conclusion it would be necessary to set up some sort of an organization from coast to coast in order that all accidents might be investigated properly. Who or what was at fault? Was it the vehicle? Was it the driver? Was he speeding? Was he drunk? Were the roads bad?

Under the chairmanship of Dr. Harold Elliott, a neurosurgeon from Montreal, such a foundation is being started in Canada to include the whole Dominion. We trust that in five or six years' time we may have some idea of the common cause of most accidents.

If you will pardon me for just a moment, I would like to tell you an amusing story. Just after this conference was held, I happened to come down to Boston on holiday. I drove down with my wife and two children in an open car, a Buick. I was driving home; it was 4 P.M., the road was dry, and it was sunny. My wife and I were in the front seat, separated by a pillow.

The two children were in the back, lying on the floor. They had gone to sleep. I think everybody was a bit tired and we were near home. All of a sudden the accident occurred. I did not remember anything until I was told about it by the State trooper afterwards.

This is what apparently happened. At the meeting, a Chief of Police had given me a few inside tips. He said, "You know, if you see a large telegraph pole made of wood, and it is not more than 1 foot in diameter, the thing to do if you cannot avoid it is to charge it."

Apparently, two drivers were proceeding up the hill from Newport. Right at the top is a state trooper's lodge. I imagine I saw the two cars approaching, and I must have realized that I could not avoid them. There was apparently a deep ditch and a row of telephone poles on my right. I took the man's advice subconsciously, and I hit the pole at full speed. In fact, I stepped on the accelerator and must have been going 90 miles an hour when I hit the pole. I took out the whole middle section from it, 4 feet long, and hurled it into the field. I, myself, awakened in the middle of the field with the car completely stable. The children were hardly awakened, and apparently I had thrown the pillow in front of my wife. Neither headlight nor windshield was smashed and I drove the car home.

I would not have believed all this, but if any of you wish to consult the state trooper in Vermont, he will give you the facts and figures as he witnessed the whole scene.

We must find out the cause of this daily increasing disease which we are faced with. I would like to congratulate the previous speaker on his splendid presentation of the problem.

MODERATOR WHITE: I have a question on seat belts. Does their use materially reduce automotive injuries? I would like to ask Mr. Fansler if he would answer that question. Do you have any information regarding this?

MR. FANSLER: Is Dr. Preston Wade in the audience? I would like to pass that question to him, not that I am trying evade it but his experience has been much greater.

DR. PRESTON WADE: Dr. Braustein and I just published something on this. Let him tell us.

DR. BRAUSTEIN: We have studied some 300 cases of accidents in which seat belts were in use, and we were able to find from a control study of 10,000 cases, eighty-one of which compared in all aspects with the seat belt cases, a maximum demonstrable improvement of about 60 per cent.

In other words, the best we could expect from the survey was 60 per cent improvement. These accidents were really quite dramatic. Many of them that were studied were high-speed accidents, usually in rural areas. Those in which seat belts were in use showed a marked improvement.

MODERATOR WHITE: I am a little hesitant to ask this question. What fraction of automobile injuries are associated with the use of alcohol? Do any one of you gentlemen have any information on that? Dr. Goddard?

DR. GODDARD: I will tackle part of that. I think I can give you some information, first of all, on fatal accidents.

There have been some studies in limited areas of this country which indicate that as high as 50 to 55 per cent of the drivers killed in motor vehicle accidents have blood or brain alcohol levels in excess of .15. The most reliable survey of cases was collected over ten years. It involved brain alcohol levels on every fatal accident in a large suburban county. The survey showed that somewhere in the range of 45 per cent of those killed had the .15 brain alcohol level.

Similar studies have been carried out in New Jersey and selected counties in some areas of Maryland. We need a great deal more data on non-fatal accidents. We have very confusing pictures in the non-fatal accidents, and it is largely related to the problems of law enforcement. The patrolman hesitates to charge a driver with driving under the influence of alcohol unless he is certain he can get a conviction. In a state like New York, only 2 per cent of the accidents are listed as being caused by alcohol. The medical profession is deeply involved in this problem because of the question of physician-patient relationship and the right of the physician to take a blood alcohol test. This has caused serious problems in some areas in upstate New York.

DR. POWERS: I can add a bit of information to that. Ten per cent of the patients in the survey of 492 accidents to which I referred admitted to drinking recently before the accident occurred. How many more had been drinking, and did not admit it, is hard to say. Ten per cent admitted to having been drinking just previously or within an hour or two before the accident occurred.

MR. FANSLER: There is no question at all but that alcohol is a serious problem. We do have a summary page of what is known in our publication "Accident Facts." In cases which have been definitely established, bearing in mind what Dr. Goddard said about the difficulty of establishing legally this idea of driving while under the influence of alcohol, a drunken driver was involved in about 30 per cent of all fatal traffic accidents in 1956. That figure is creeping up. The best figures that we were able to obtain a few years ago showed only a much, much smaller percentage than that. It may be due to better reporting.

MODERATOR WHITE: In view of the fact that a great deal of the discussion has boiled down to the implications of the automobile accident, and due to the fact that we, as a specialized group, should really know more than the average person about the consequences and something about the prevention of accidents and injuries, I would like to know just how many of us, by a show of hands, have seat belts and use them in our cars. I think it is very encouraging. There are a few hands that are not raised, but the conclusion to be drawn is that perhaps we ought to start educating ourselves before our communities.

MR. FANSLER: How many of you put on seat belts and strap yourselves in every time you get into the automobile? Well, about the same number. Congratulations to you people. I think seat belts are a real safety device.

MODERATOR WHITE: Are there further questions from the floor? If not, it would appear to me that the mantle of responsibility in the prevention of accidents has slowly settled on our shoulders. I think it behooves us to activate ourselves in this direction.

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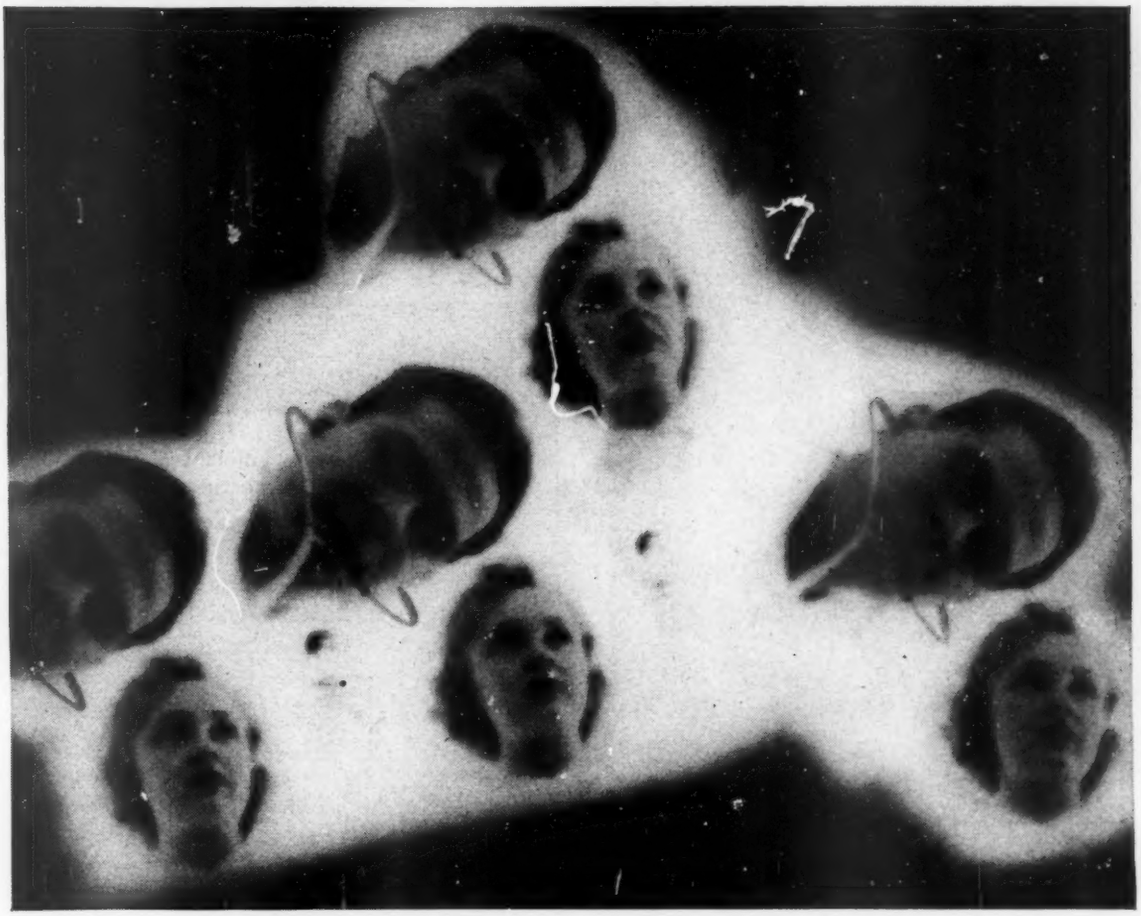

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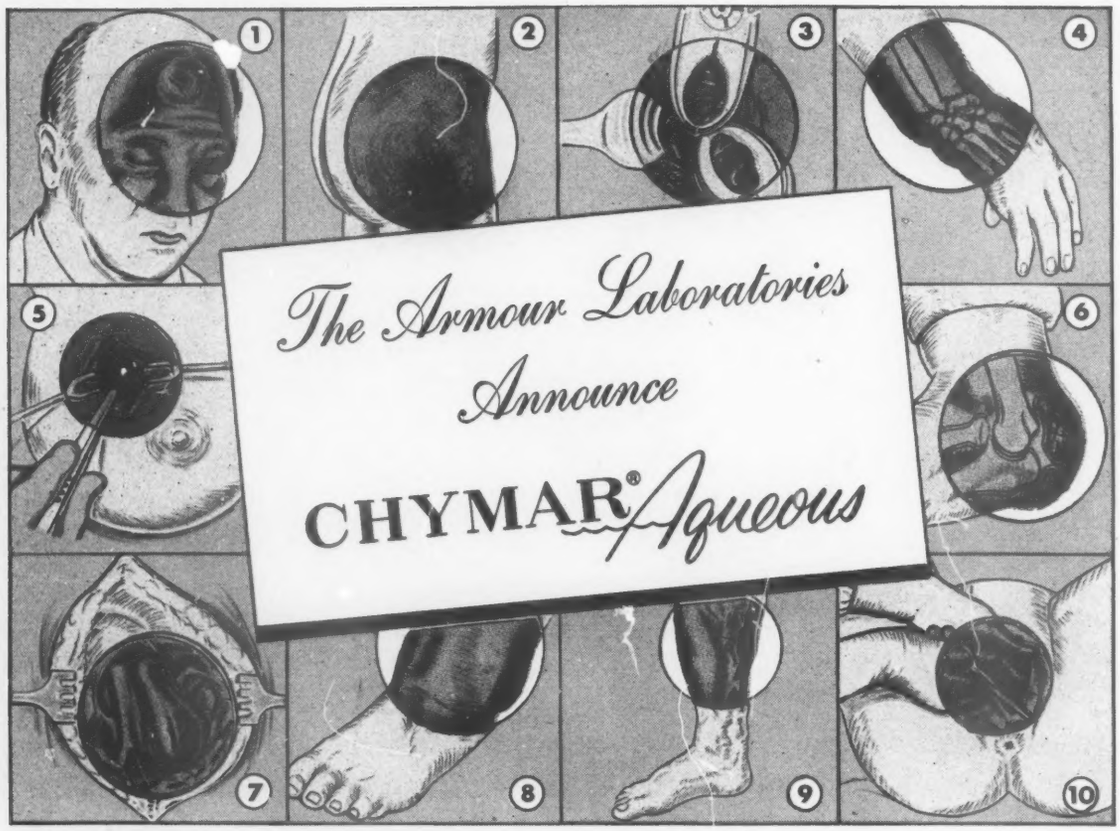

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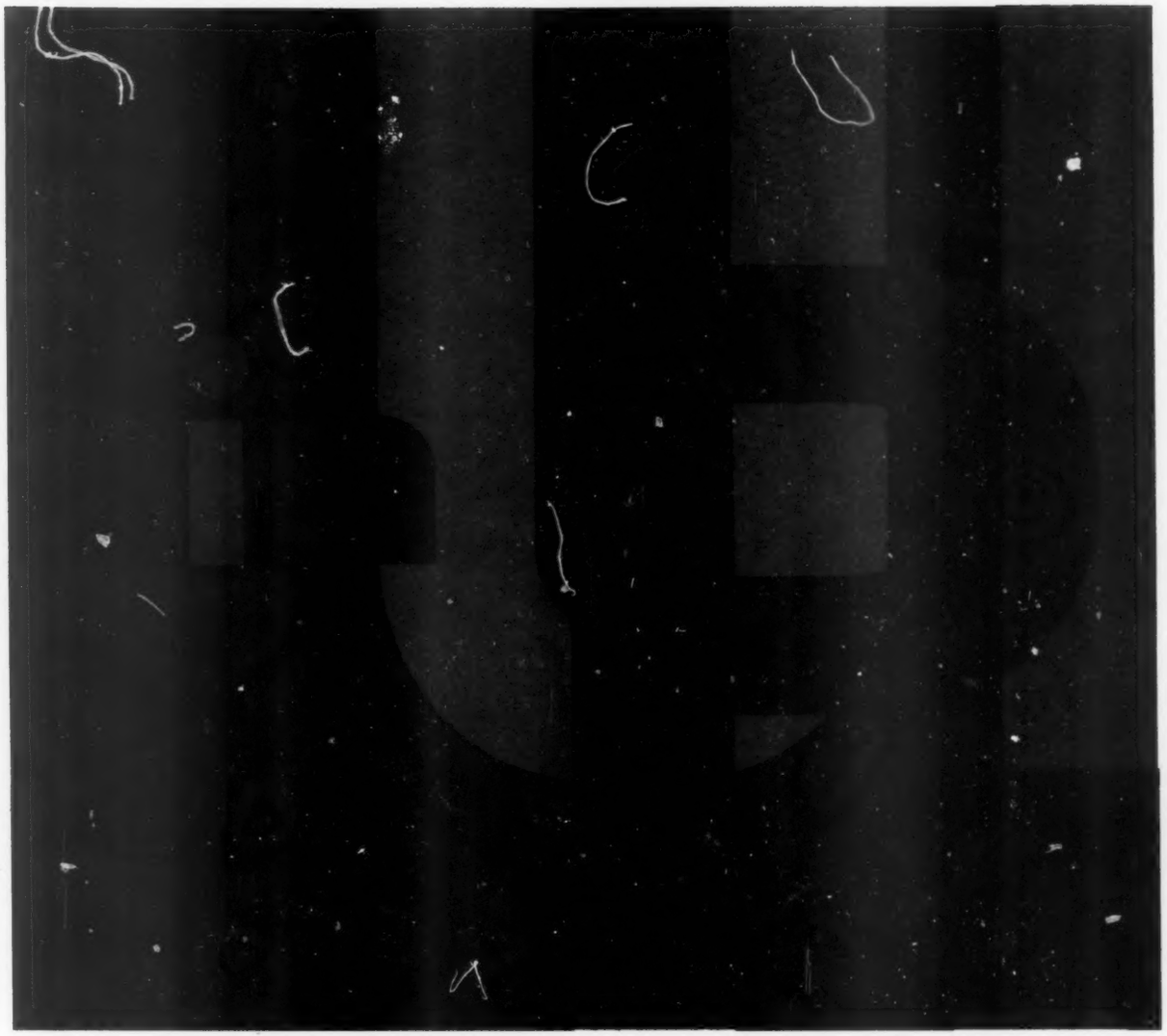

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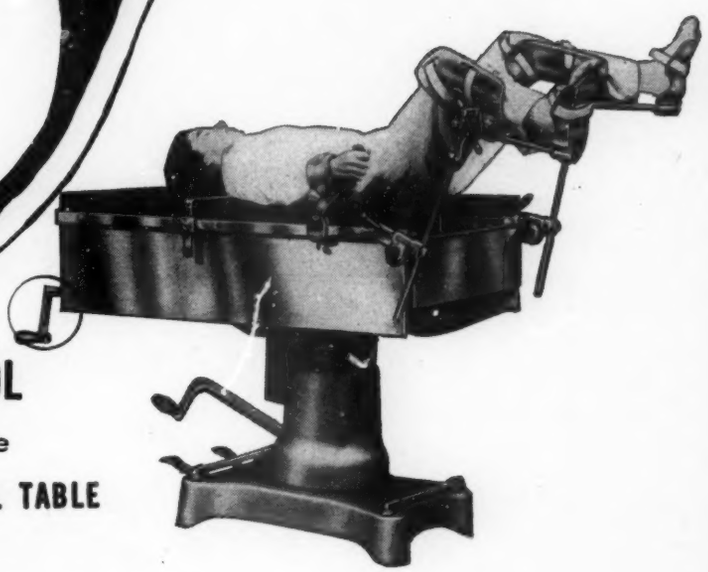

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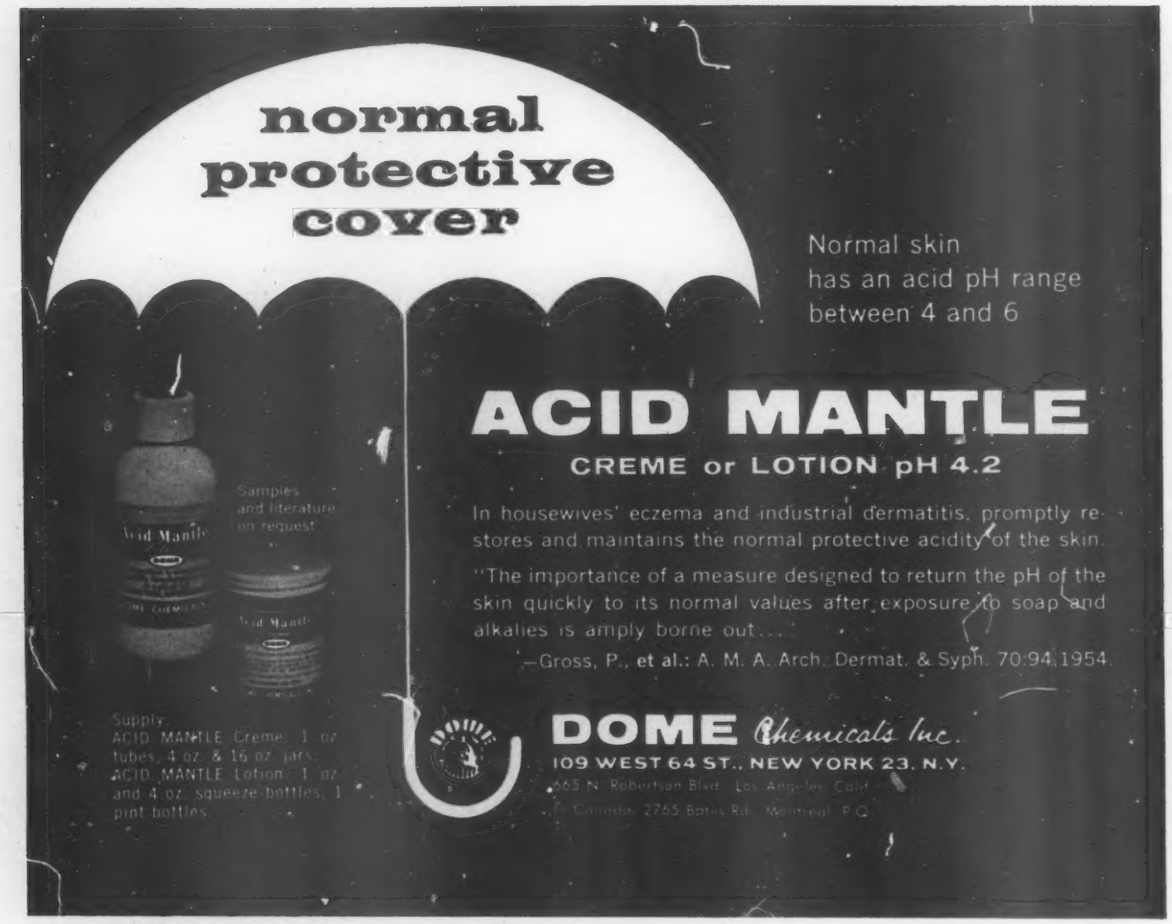
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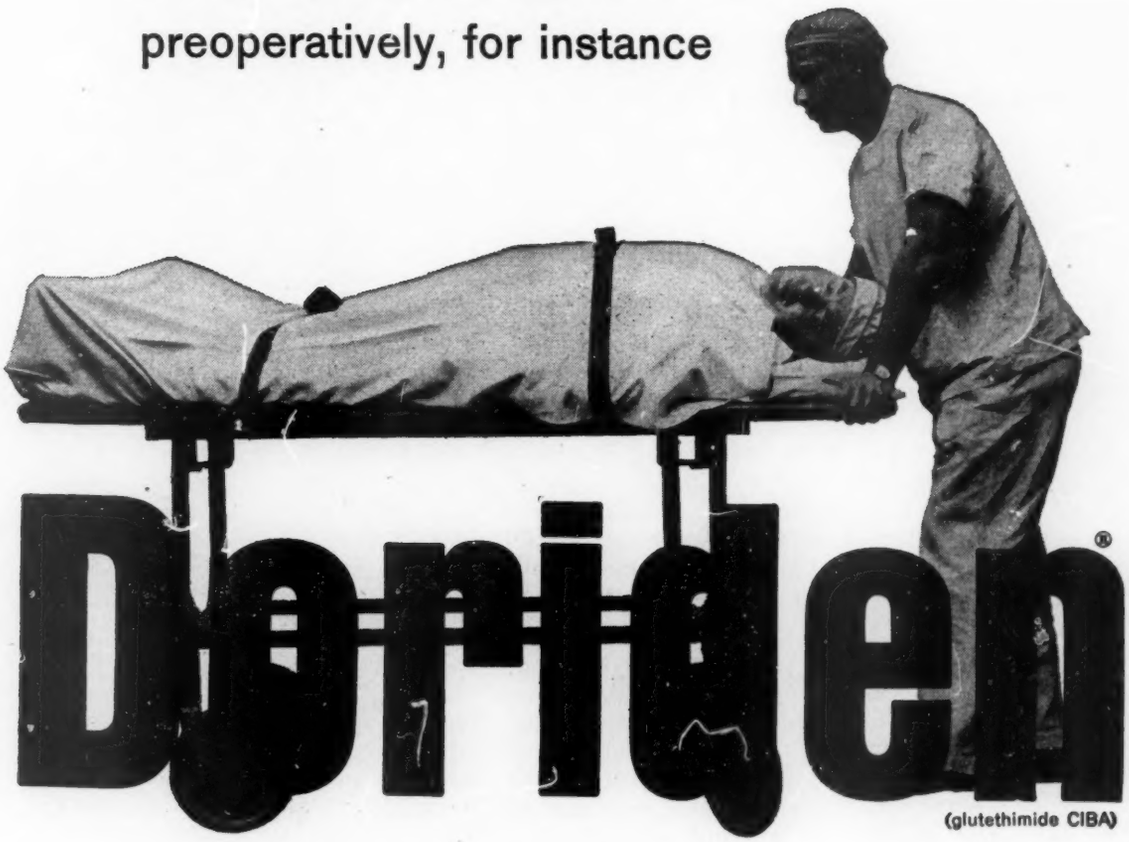

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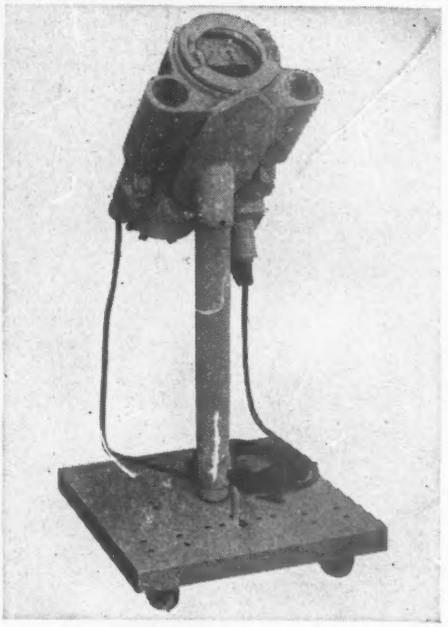

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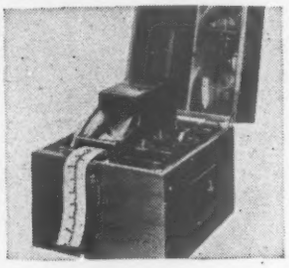

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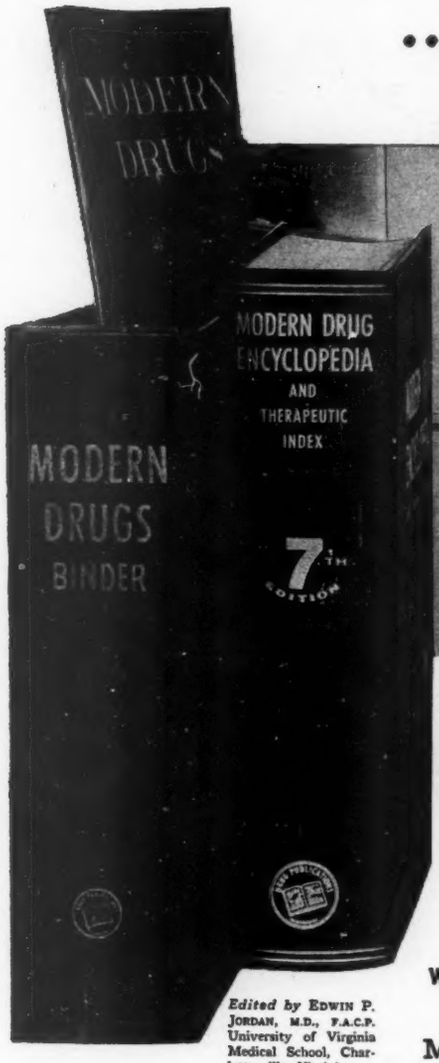

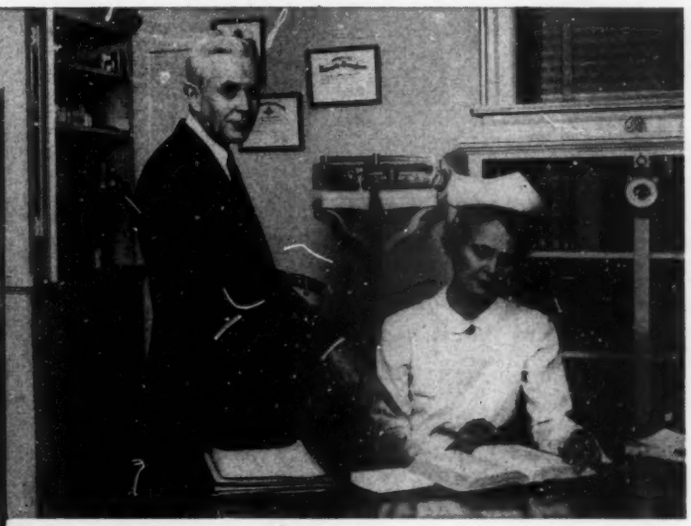

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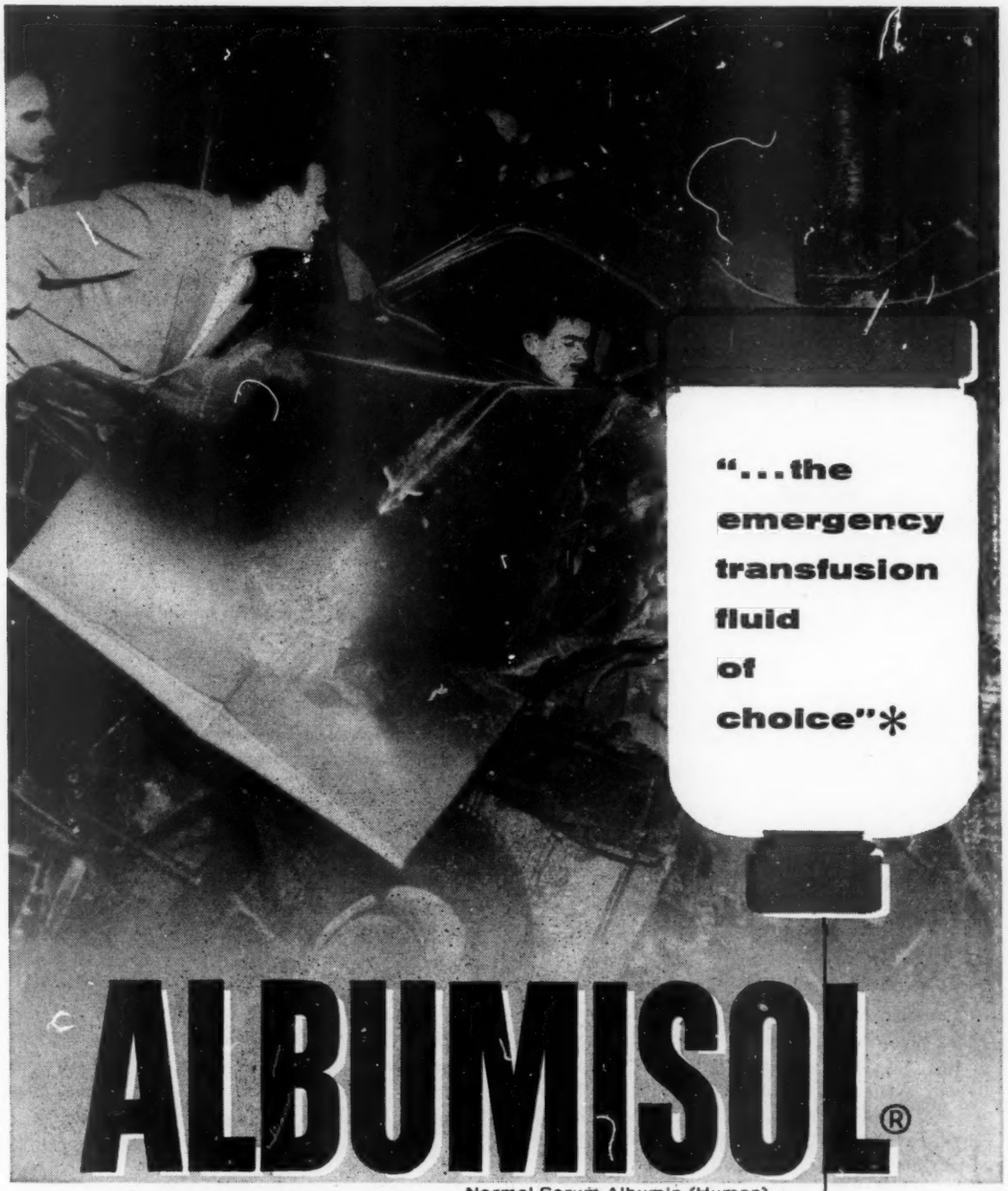

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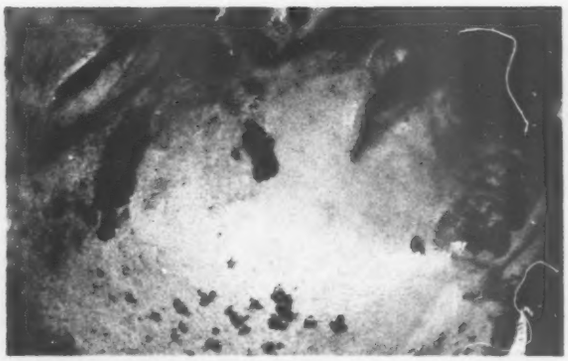

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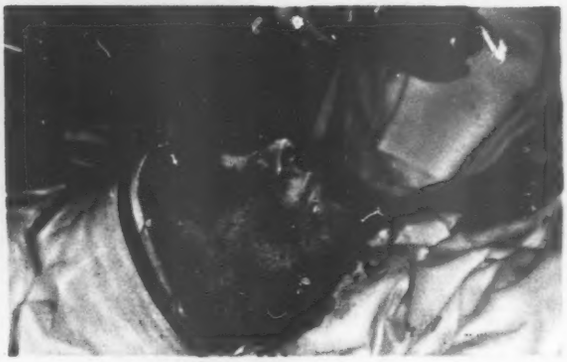

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5. *Wilkins, B.D.: Gastrointestinal Bleeding as Seen by the Proctologist, J.A.M.A. 163:1214 (April 6, 1957)*
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7. *N.N.R., 1957, p. 265*

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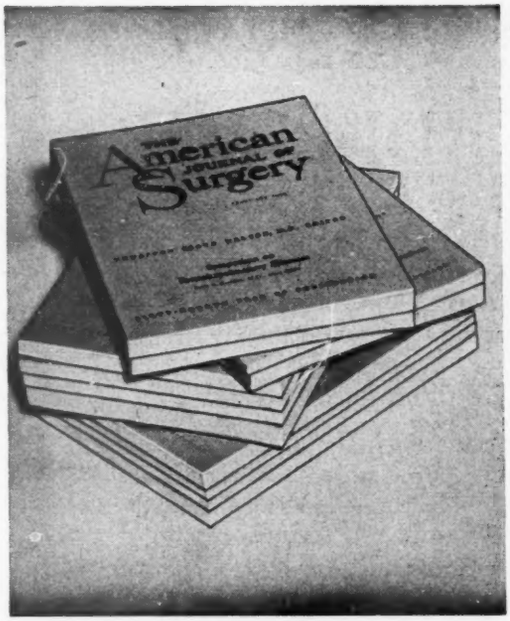

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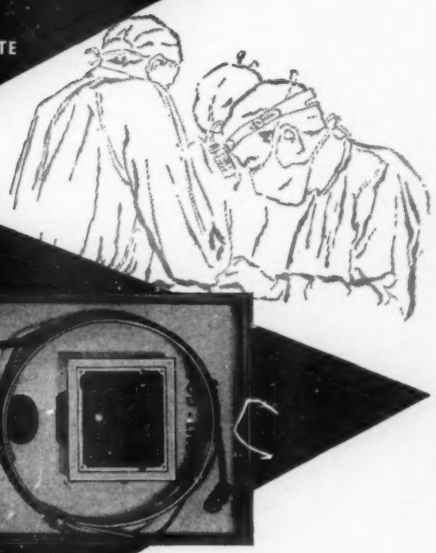

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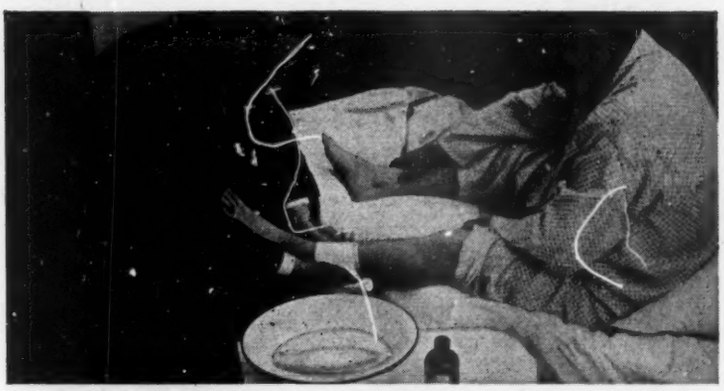

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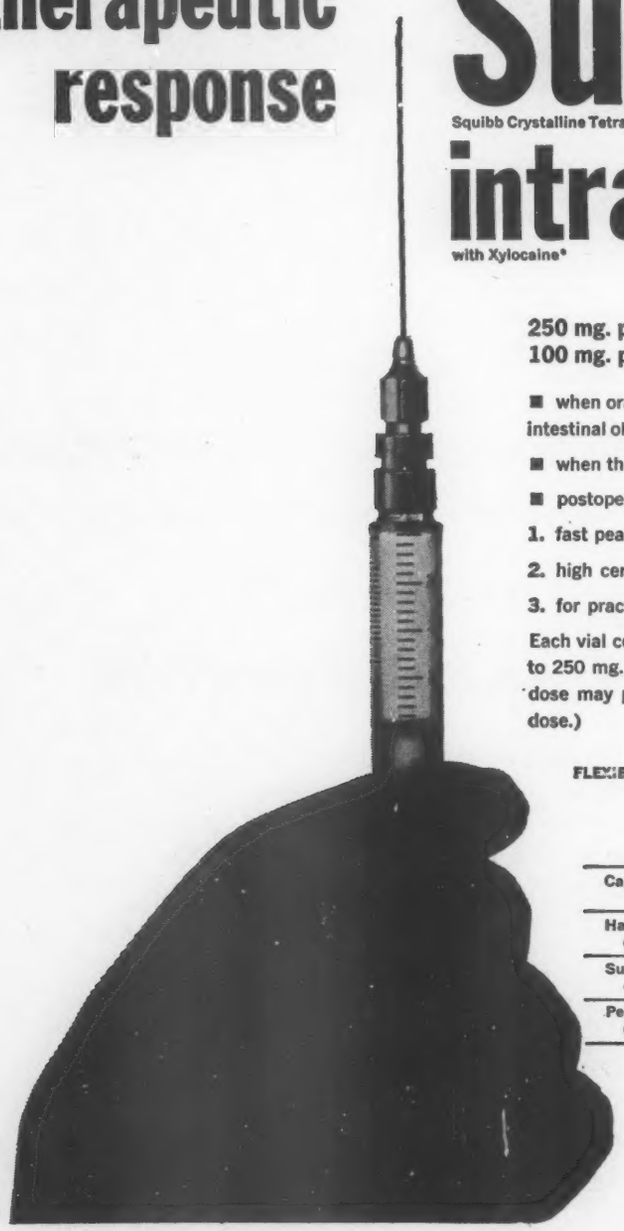

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1. Carlozzi, M.: Antibiotic Med. & Clin. Therapy *5*:146 (Feb.) 1958.

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NOTES AND QUOTES

POCKET-SIZE AEROSOL DISPENSER FOR ASTHMA RELIEF. Winthrop Laboratories has introduced isuprel® Mistometer, a pocket-sized, metered-dose aerosol dispenser which relieves bronchospasm and the accompanying anxiety in asthmatic patients more rapidly than standard hand-bulb inhalers.

The isuprel Mistometer is a completely self-contained unit, yet it is small enough to be concealed in the hand. It consists of a 10 cc. vial of the potent bronchodilator isuprel hydrochloride (isoproterenol), 0.25 per cent aerosol solution, plus a detachable plastic mouthpiece with built-in nebulizer and protective cap. The bronchodilation resulting from a single inhalation is equivalent to approximately ten inhalations from hand-bulb nebulizers.

Use of the new isuprel Mistometer is recommended by Winthrop for its swift antispasmodic action and its effect in allaying the patient's feelings of anxiety, which intensify bronchospasm in asthma. It is equally effective in treating chronic bronchitis and pulmonary emphysema. Its safety was established in over 1,000 clinical trials with adults and children, without a single case of irritation reported.

Principal advantage of the Mistometer unit, in contrast with hand-bulb inhalers, is its unvarying precision in delivering the required dosage.

NEW AGENT FOR TREATMENT OF COLONIC DISORDERS. *A new anticholinergic agent cantil® (Lakeside) is both effective in the treatment of functional and organic disorders of the colon and "singularly free of the side-effects commonly encountered with anticholinergics," according to a report by Dr. Jacob Riese of the Jersey City Medical Center* (Am. J. Gastroenterol., *28: 541, 1957*).

Dr. Riese describes a study conducted with the drug on seventy-nine patients suffering from such disorders as ulcerative colitis, irritable or spastic colon and infectious gastroenteritis. He found that approximately 90 per cent of the patients had their symptoms controlled or eliminated after administration of cantil.

The new agent differs from other anticholinergics in that it has a high selectivity for the colon, thus fulfilling the clinician's need for a drug that can restore normal tone and motility to the colon while exerting little or no clinically significant efforts elsewhere.

In forty of forty-four cases of irritable or spastic colin, cantil "reduced or abolished abdominal pain, diarrhea and distention and prompted restoration of normal bowel function," Dr. Riese states.

The drug also proved "very helpful" in the management of ulcerative colitis, relieving its symptoms and checking hemorrhage. It "helped effect remissions of diarrhea and cramps in fourteen of sixteen patients."

IDENTIFICATION AND MEDICAL RECORD WRIST BAND. Certain pertinent information is essential for identification and emergency treatment in the event of sudden illness, injury or mass catastrophe. As a key to emergency treatment, Dr. M. L. Brodny has devised "Medilog," a unique watchband or bracelet in which is incorporated an especially constructed compartment designed to contain an accordian-folded miniature medical history and identification record. This abbreviated form is so constructed that all pertinent information can be concisely recorded and easily read. "Medilog" is organized in the following sequence: Personal identification; notification (social, medical); travel identification; legal data; miscellaneous; present illnesses; hematologic status; unconsciousness; allergies; heart disease; past history; miscellaneous. Dr. Brodny believes that universal adoption of "Medilog" will save lives, decrease morbidity, prevent complications and make possible immediate identifications and early notification.

MORE ABOUT CANCER. *Early detection of cancer can often lead to successful treatment or at least to substantial relief even in persons of advanced age, it is emphasized by the Metropolitan Life Insurance Company.*

Periodic health examinations of the elderly are a practical means of early detection, the company points out, adding that educational measures suitable to persons in later life should be devised to make these people aware of the danger signals that may mean the presence of cancer.

Cancer ranks among the foremost problems of geriatric medicine. In 1956 there were more than 126,000 deaths from cancer in the United States among persons at ages sixty-five and over. In

CONTINUED ON PAGE 52

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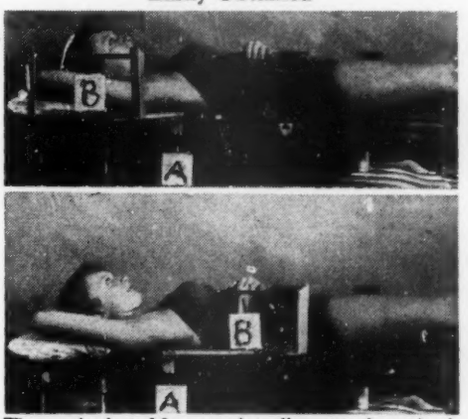

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that age group, cancer as a cause of death is outranked only by heart disease and cerebral hemorrhage, and accounts for about 15 per cent of the total mortality in this group.

The statisticians estimate that at present there are about 365,000 new cases of cancer each year among persons over sixty-five, and that in one of every four persons reaching that age cancer will eventually develop. In the course of a year, there is one new case of cancer among every sixty-five men at ages sixty-five to sixty-nine; the proportion is one in thirty-three at ages eighty-five and over. Among women, the corresponding rise is from one case in every eighty to one in every forty-four.

Among women over sixty-five the reproductive organs, breast and intestines are numerically the most important sites of fatal cancer. Among males in the sixty-five to seventy-four year old age group, cancer of the respiratory system outranks every other site, and accounts for nearly one-fifth of the deaths from cancer at those ages—a mortality rate for this site nearly six times that for women. At ages seventy-five and over, the prostate is the leading site of fatal cancer among men, taking a considerably larger toll than cancer of the stomach, which ranks second.

The skin is not a major site of fatal cancer at any age, even though it is one of the most common sites for the occurrence of the disease.

NEW INSTRUMENTS FOR SURGEONS AND CARDIOLOGISTS. Two startling new tools for the cardiologist and surgeon have become available through American Electronic Laboratories, Inc., Philadelphia. They are both the result of many man-years of research and careful analysis of data.

First, the Intracardiac Phonocatheters are available as single-lumen devices for the detection and recording of internal heart sounds and as double-lumen units for both sound detection and simultaneous internal pressure measurement, sample withdrawal or dye insertion. Complete self-contained transistorized preamplifiers are also furnished. These are designed from a practical point of view to feed directly into standard electrocardiographic recording equipment. These instruments have already been used effectively in the diagnosis of over 100 cases.

Second, the Cuvette-Oximeter and Dye-Detector represents a major advance in instrumentation for heart output work and percentage blood-oxygen saturation determination on either a sample or continuous flow basis. This instrument has a sample capacity of only 0.85 cc. and is not sensitive to either hematocrit or flow between 0 and 20 ml./minute. As an Oximeter it reads instantaneously on a linearly scaled indicating panel-meter marked 0–50%, 50–100% and 0–100% saturation. For use with recorders, either 10 volts or 1 milliampere full-scale signal is available which is sufficient to operate standard in-writing or photographic recorders with no additional equipment required.

The Oximeter can be used directly as a detector for Evans' Blue, and by throwing a single switch becomes a highly sensitive detector for tricarbocyanine 11 (Fox Green). The instrument is impervious to power line variations experienced in many laboratories and hospitals, and needs no batteries for its operation.

SYNTHETIC ANTIMICROBIALS. *It is possible that the day of the antibiotics may be drawing to a close in some important areas and that the "future of antimicrobial therapy may well rest with antibacterial chemicals . . ."*

This is the conclusion drawn by Drs. Harry Seneca and John K. Lattimer, Columbia University College of Physicians and Surgeons, from a study of cross resistance of a number of strains of staphylococci to antibiotics and antibacterial chemicals. "It is reassuring to observe that no resistance was manifested against chemical antibacterials, such as nitrofurantoin (furadantin®) and sulfadiazine" (Archives of Pathology, *November, 1957*).

Their in vitro *study shows that penicillin resistance makes staphylococci more resistant to other antibiotics. Seven strains of Micrococcus pyogenes var. aureus, which were resistant to penicillin concentrations of 50,000 units per ml., were tested against various antibacterial drugs. Resistance to penicillin increased sixty-three fold, and from two to sixty-four fold to other antibiotics and antibiotic combinations. Only novobiocin, along with the antibacterial chemicals, showed no increase in resistance, but the authors maintain "it is only a question of time for resistance to develop against novobiocin."*

CONTINUED ON PAGE 54

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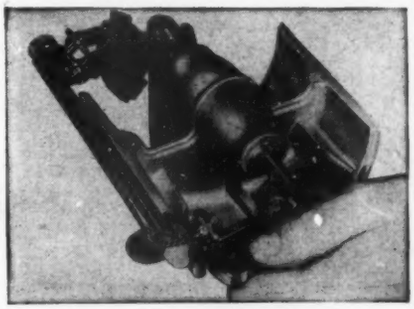

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FRACTURES AND OTHER TRAUMA. The second annual Post Graduate Course in Fractures and Other Trauma will be given by the Chicago Committee on Trauma of the American College of Surgeons, for four days from Wednesday, April 16th through Saturday, April 19th, at the John B. Murphy Memorial Auditorium, 40 East Erie Street, Chicago. Topics will include trauma to the hand, head, chest, abdomen, heart, knee and shoulder, treatment of burns, athletic injuries, and other subjects selected in answer to a questionnaire sent to last year's registrants. Illustrated lectures, patient demonstrations, and question and answer periods will also be held. Registration fee is $50.00. Residents, interns and students will be admitted free if a note of identification from chief of service or dean is provided. All inquiries may be addressed to Dr. John J. Fahey, 1791 W. Howard St., Chicago 26, Illinois.

DEVICE TO LOWER BODY TEMPERATURE. *A newly developed device that can lower a patient's body temperature 10 degrees in as little as five minutes is now in use at the Duke University Medical Center, Durham, North Carolina.*

The device was reported on by Dr. Wirt W. Smith of the Duke surgery staff at a Conference on Methodology and Problems in Artificial Internal Organs held at the Rockefeller Institute. Called a blood heat exchanger, it marks a new advance in safeguards for patients who undergo complex open heart surgery.

Formerly patients were cooled with ice packs or refrigerated blankets. This process took an hour or longer and was hard to control in terms of desired temperatures. Now, Dr. Smith said, surgeons using the heat exchanger can lower a patient's temperature at an average rate of 1°F. every thirty seconds, raise it with almost equal speed and control it within an accuracy of ½ degree.

The heat exchanger is being used at Duke in heart operations that involve an "artificial heart-lung" machine combined with hypothermia, or lowering of the patient's body temperature. The heart-lung machine takes over the work of a patient's own heart and lungs. The surgeons can open the heart and repair congenital defects such as holes or obstructions.

Lowering the patient's temperature greatly reduces his oxygen needs and permits lower blood flow rates through the heart-lung, thus protecting the brain and other vital organs. Hypothermia also lessens damage to blood cells and reduces the chances of certain complications.

AMERICAN BOARD OF OBSTETRICS AND GYNECOLOGY. The next scheduled examinations (Part II), oral and clinical, for all candidates eligible, will be conducted at the Edgewater Beach Hotel, Chicago, Illinois, by the entire Board from May 7 through 17, 1958. Formal notice of the exact time of each candidate's examination will be sent him in advance of the examination dates.

Candidates who participated in the Part I examinations will be notified of their eligibility for the Part II examinations at the earliest possible date.

Current Bulletins of this Board may be obtained by writing to Dr. Robert L. Faulkner, 2105 Adelbert Road, Cleveland 6, Ohio.

DU PONT'S AID TO EDUCATION. *Grants totaling nearly $1,150,000 have been awarded to 135 universities and colleges in Du Pont's annual program of aid to education, the company announced. The total for the next academic year is about $100,000 more than Du Pont contributed for this last school year.*

Most of the increase and more than half of the entire program are grants to colleges and universities for strengthening the education of scientists and engineers. These grants will support the teaching of science and mathematics as well as other subjects. At the same time, grants for fundamental research are being continued, as are grants for fellowships, which once made up the entire plan. Du Pont's program dates from 1918.

As in previous years, decisions on the use of the funds and the selection of people to receive individual grants are left to the institutions.

In recent years, discussions with educators have indicated that maintaining high standards of teaching is a major problem at all levels of education in view of higher costs and increasing enrollments. Du Pont's grants for advancing teaching, which proved effective in science, mathematics and other liberal arts courses, are now being extended to medical schools for the first time.

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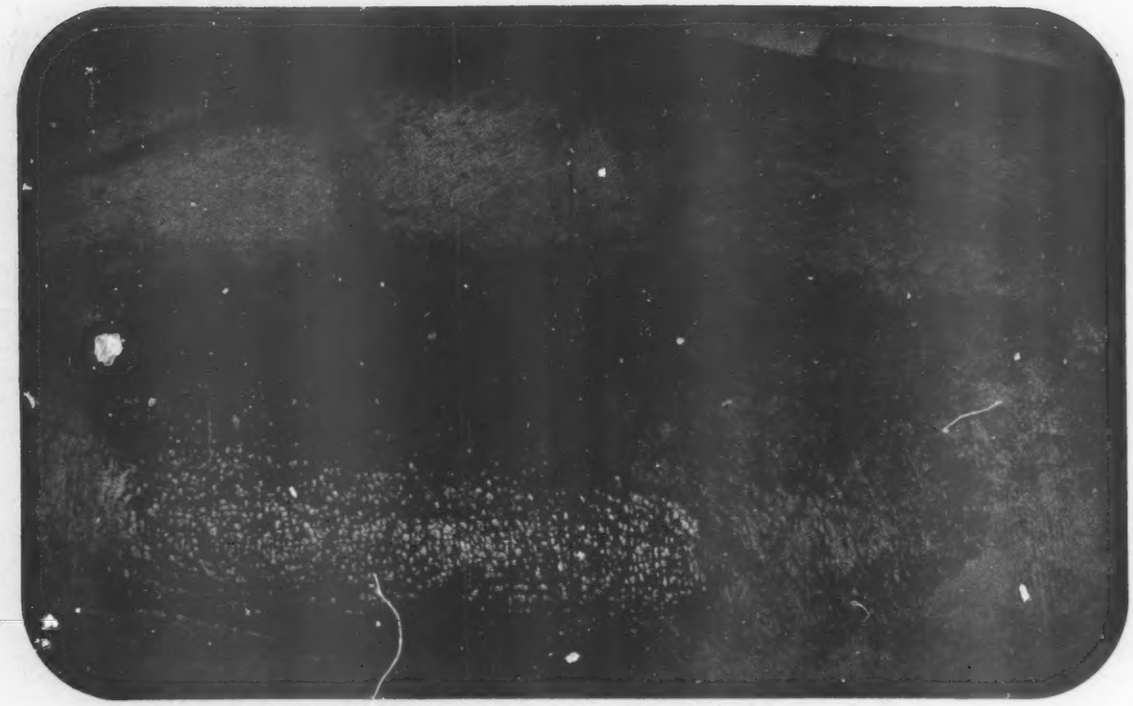

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Jeffords, J. V., and Hagerty, R. F.: Ann. Surg. *145*:169, 1957.

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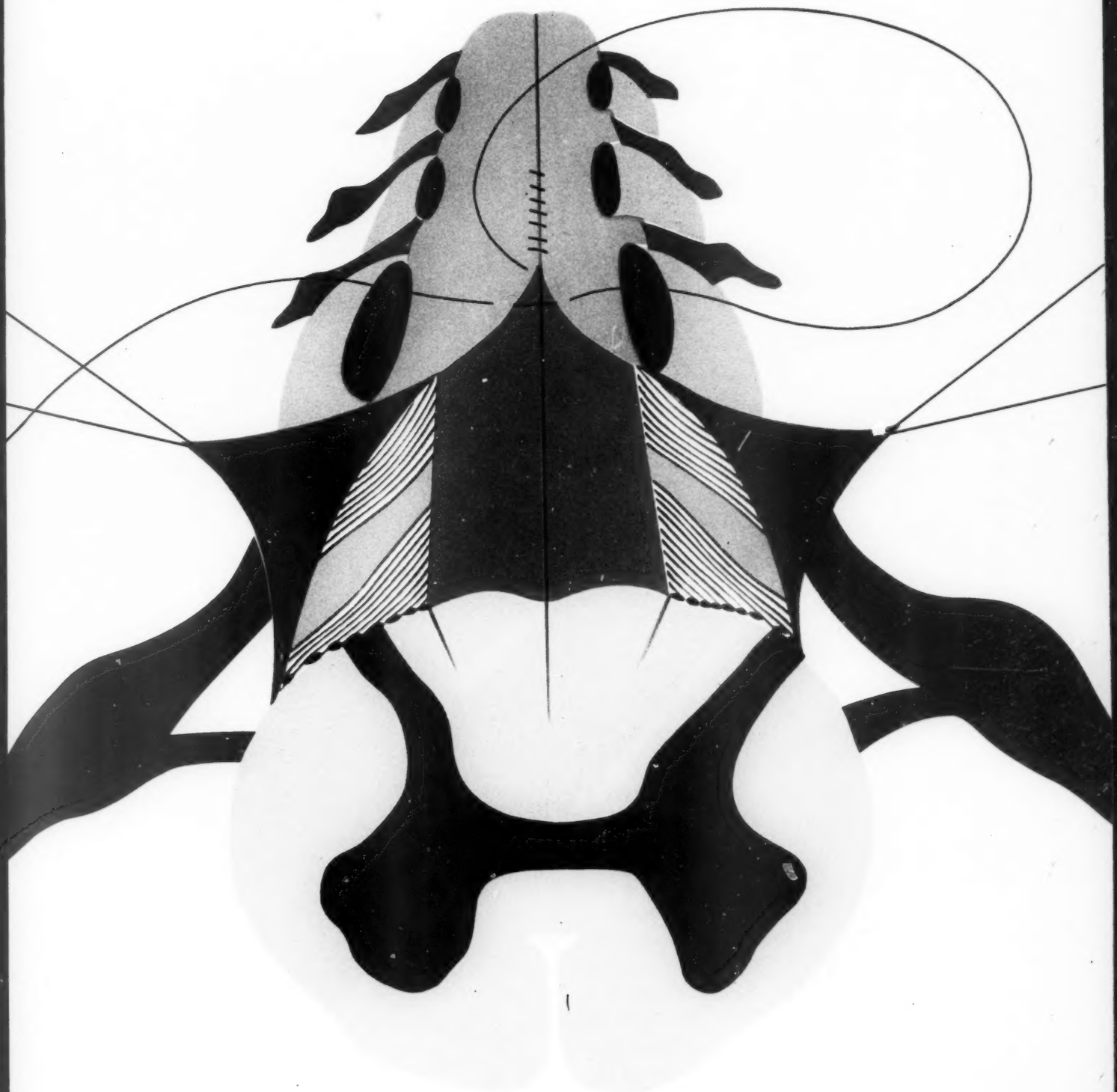

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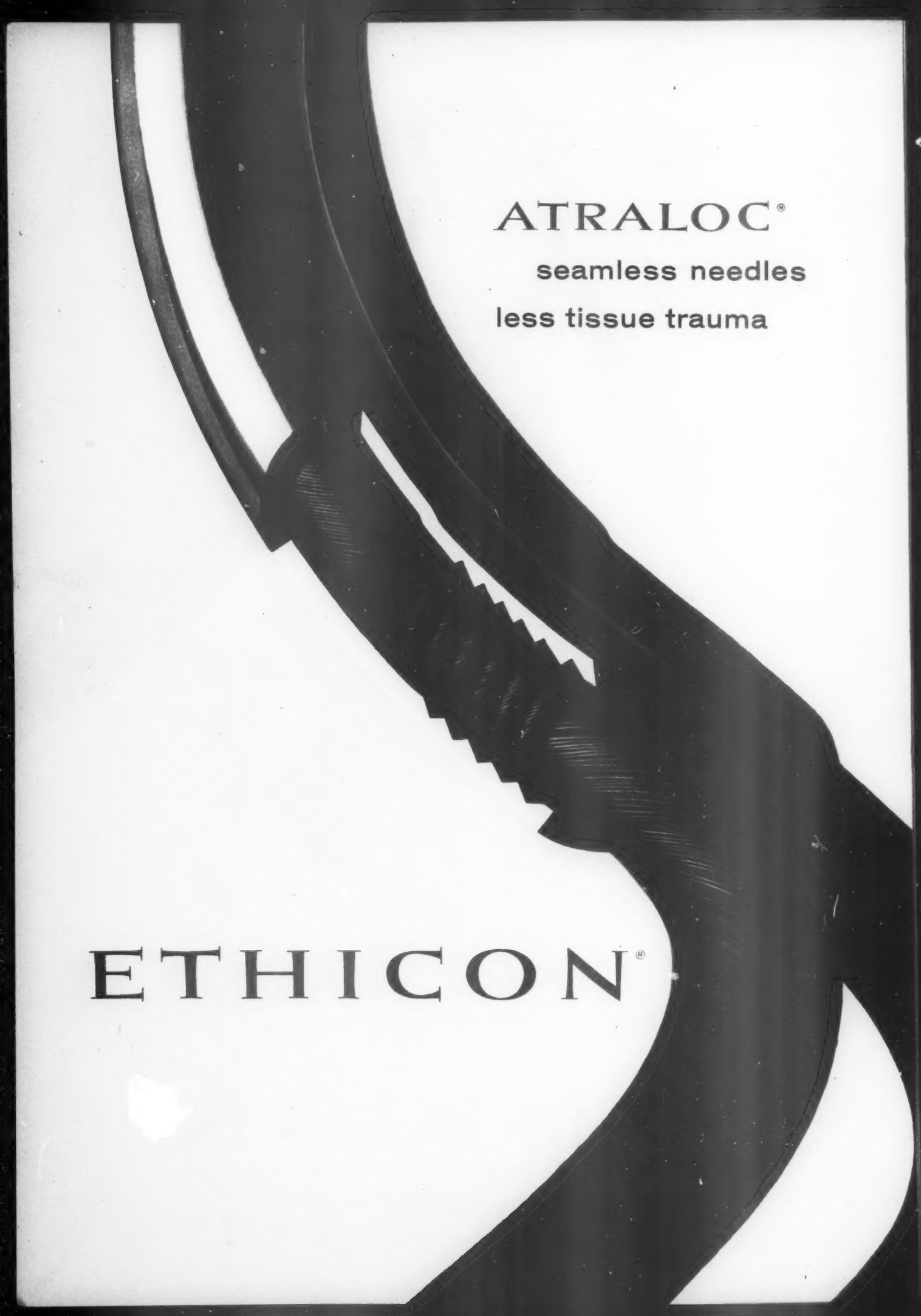
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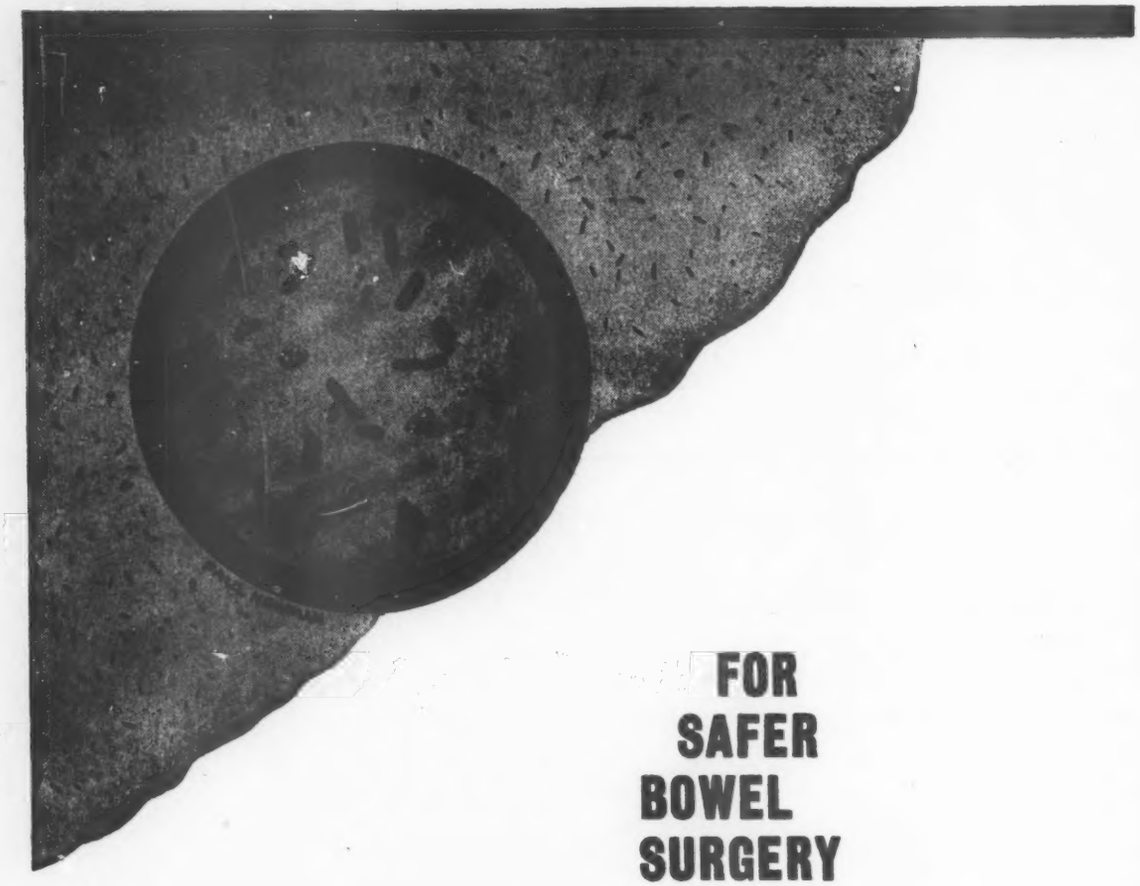

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